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INSTITUTIONAL CHANGE IN U.S. COTTON PRODUCTION, 1920-60

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Abstract

Between 1928 and 1960 U.S. cotton production witnessed a revolution with average yields increasing roughly threefold. In addition, the average staple length of the U.S. crop increased significantly, reversing a long-run downward trend in cotton quality. Underlying these accomplishments were major innovations in cotton marketing, wholesale changes in the varieties grown, and the emergence of a vibrant commercial seed industry. This paper analyzes the key institutional and scientific developments underlying this revolution in biological technologies, pointing to the importance of two government programs—the one-variety community crusade and the Smith-Doxey Act—as catalysts for change.

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HOG ROUND MARKETING, SEED QUALITY, AND GOVERNMENT POLICY: INSTITUTIONAL CHANGE IN U.S. COTTON PRODUCTION 1920-60[1]

During the twentieth century American cotton farming evolved from a backward sector to a highly productive industry. For the most part, the history of the modernization of the cotton industry has concentrated on mechanization and the end of sharecropping to the virtual exclusion of any serious analysis of the enormous advances in biological technologies.[2] This omission is surprising given the emphasis devoted to the role of improved varieties in generating productivity growth of other crops and other regions. Most notable are the studies on the development and diffusion of hybrid corn.[3] The lack of attention to new cotton varieties should not suggest that no change occurred. To the contrary, average U.S. cotton yields started their upward march at about the same time as the upturn in corn yields, and from 1928-32 to 1958-62 the rate of growth in cotton yields actually outpaced that of corn yields (see Figure 1).

This paper analyzes the role of government policy and, in particular, the one-variety improvement movement in promoting the diffusion of new, high-performing cottons. The story of the development and diffusion of new cotton varieties is far more intriguing than the often-cited accounts of the introduction of hybrid corn, in part because cotton farming was one of the most backward sectors of American agriculture. The most distinguishing characteristic of the diffusion of new cottons was the role of government policy. Once new varieties of corn became available, the story of diffusion was largely the result of the market interactions between individual farmers and private seed companies (apart from extension service educational campaigns). By comparison,

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[2] Wright, *Old South,* pp. 226-38; Street, *New Revolution*; Day, "Economics" pp.427-49; Musoke and Olmstead, "Rise of the Cotton Industry," pp. 385-412; Whatley, "Labor," pp. 905-929. The exceptions typically deal with the boll weevil. Helms, "Revision and Revolution," pp. 108-25; Osband, "Boll Weevil," pp. 627-43.

[3] Griliches, "Hybrid Corn," pp. 275-80. Modern convention uses the term "cultivar" instead of the term "variety." Because most of the literature of the period under consideration predates this terminology, we use the term "variety" throughout.

the cotton industry was long plagued by chronic problems of market failure that dulled the incentives for both seed breeders and individual farmers. To overcome negative externalities in production and a "lemons problem" in marketing, the United States Department of Agriculture (USDA) and state officials orchestrated a collective action campaign to create one-variety communities. This movement played a key role in facilitating the adoption of the new biological technologies.

YET ANOTHER BURDEN OF SOUTHERN HISTORY

The 1921 USDA *Yearbook* is representative of an extensive literature bemoaning yet another burden of southern history: "According to the testimony of the cotton trade in Europe as well as in the United States, the quality of the American cotton crop has deteriorated in recent decades."[4] The available quantitative evidence on the decline in quality in fact supports this claim. Table 1 collects data on the staple length of U.S. cotton by state circa 1880, 1913, and 1928-30.[5] In every state for which data are available, the staple length in either 1913 or 1928-30 was less than in 1880. Based on the national weighted average, staple length fell by over 12 percent over the fifty years between 1880 and 1930.[6]

The consequences of the deterioration in quality were potentially very serious given rising competition from foreign cotton, rayon, and other synthetic fibers.

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[4] Doyle, Meloy, and Stine, "Cotton," p. 400. Also see Johnson, *Cotton*, pp. 53-54. The 1866 Report of the Commissioner of Agriculture dates the problem to the war itself. "The most serious difficulty encountered by cotton-growers, and particularly those who are engaging in such enterprises for the first time since the war, had been found to be *poor seed*." The report further noted that "for seven years little or no pains have been taken by any cotton-growers to perfect their seed." U.S. Commissioner of Agriculture, *Report*, p. 209.

[5] Cotton length was one of the most important factors in pricing cotton. Cotton classers divided samples into 6 different color classes. Within each color there were a range of grades. For white cotton there were 9 specific grades that captured factors such as the existence of foreign matter, the cotton's color quality, and "ginning preparation," which included the roughness, nappiness, and stringiness of the fibers. With modern high velocity testing equipment it is now possible to cheaply determine important characteristics (such as fiber strength) that previously were difficult to assess. Cox, "Cotton," pp. 320-23.

[6] Determining exactly how the market valued this decline is slightly more complicated. The text table below shows how average prices over the 1928-30 period in ten central markets varied with staple length, taking 7/8s of an inch as the standard. (USDA, *Agricultural Statistics 1936*, p. 84).

13/16"		7/8"	15/16	1"	1 1/16"		1 1/8"	1 3/16"	1 ¼"
93	100	103	107	112		116	124	147	

Note the marginal value of increasing staple length was greater at the ends, especially at the high end, than at the middle of the distribution. Due to these non-linearities, the market value of the decline in staple length over the 1880-1930 period was larger than a comparison of the prices of mean qualities would indicate.

The causes of quality decline were twofold. First, the invasion of the boll weevil, beginning in 1892, led farmers throughout the cotton belt to discard late-maturing varieties that were most susceptible to the pest. "In this way many excellent varieties of long-staple upland cotton and practically all of the better types of medium-staple were lost within a comparatively short time, to be replaced by the early, rapid-fruiting types brought in from the northern parts of the belt."[7] But the boll weevil was only part of the problem. As indicated in Table 1, staple length also declined between 1880 and 1913 in areas not yet hit by the weevil such as North Carolina. Contemporaries noted that cotton culture was burdened by an interlocking set of production and marketing problems that both hampered the ability of and reduced the incentives for individual farmers to maintain and improve cotton quality. Cotton production was plagued by a number of negative externalities that made it difficult to maintain the genetic purity of the seed supply. These technical difficulties were exacerbated by post-Civil War institutional changes, in particular the break-up of the plantation units into small operations and the increased importance of public gins. In addition, the prevalence of a form of pooling contract known as the hog round system muted price incentives to produce high-quality cotton. A "vicious circle" thwarted efforts to improve the crop and reduced demand for quality seed. This, in turn, reduced incentives for seed breeders to invest in R&D, further reinforcing the low-level equilibrium trap.[8]

On the production side, problems of maintaining purity arose because cotton is subject to cross-pollination. The incidence of cross-pollination varies greatly depending on the variety, weather conditions, the distance between fields, and the population of insects (especially bumble bees). When cotton was cultivated in small fields located near woodlands that provided habitat for feral bees—conditions common across much of the South in 1900—cross-pollination rates could easily exceed 40 percent. But when it was grown in large mono-variety fields that were frequently sprayed with insecticides, as was common in the Mississippi Delta by the 1950s, the annual cross-pollination rates were likely less than a few percent.[9] The median rate of natural crossing between

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[7] Ware, "Plant," p.661.

[8] Burges, "Break This Vicious Circle," pp. 5, 6, and 29.

[9] Brown, *Cotton*, 1st ed., pp. 165-66. Cook describes several cases in which early efforts to grow Durango and Egyptian cottons in California failed because of cross-pollination with shorter-staple cottons. Cook, "One-Variety Cotton," pp. 10-11.

Cross-pollination rates in today's cotton are lower because the plants have evolved to self-pollinate after the increased use of pesticides led to the destruction of the pollinating insects.McGregor, "Insect," pp. 171-90D; Simpson, *Natural Cross-Pollination*.

alternate rows reported in ten studies across the South over the 1903-50 period was between 8 and 9 percent.[10]

Maintaining pure seed lines became an increasingly serious problem after the Civil War with the emergence of public gins and changes in ginning technology. According to the USDA roughly 90 to 95 percent of the seed used to plant the U.S. cotton crop in the 1920s and early 1930s was mixed "gin-run" quality.[11] (Even when farmers purchased seed rather than used their home-grown product, the "outside" seed was often simply gin-run seed from other areas.) Prior to 1850 the typical plantation gin was animal powered and processed only three to four bales per day of cotton grown in the gin's immediate neighborhood. With the spread of steam power and other important innovations, gin capacity increased and the supply area expanded. The major breakthrough occurred in the mid-1880s with the invention by Robert Munger of "system ginning" that employed pneumatic and mechanical conveyance technologies and multiple stands of gin equipment. This represented one of the major technological advances in the New South. By 1900 the prototypical modern ginnery, containing four gins of seventy saws each, could process 40 to 60 bales of cotton per day and some were capable of handling 150 bales per day. The new "system" gins were much more efficient than the older methods, but their complicated machinery and larger clientele led to the unintended consequence of substantially increasing the problem of seed mixing.[12]

Numerous studies have demonstrated that seed mixing in successive gin runs was a very serious problem (the smaller the runs the greater the problem).[13] For example, the USDA estimated that "seed from a farmer's first bale at the gin contains 26 percent of the seed from the preceding bale…."[14] Investigators reported cases of farmers receiving seed not only from the previous farmer to use the gin but those three or four turns earlier. Given the practices of the day, gin operators were apt to indiscriminately return seed to farmers even if the growers requested their own seed.

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[10] Brown and Ware, *Cotton*, p. 158.

[11] Doyle, "Multiplicity," p. 108; Doyle: "Cotton," p. 264

[12] Bennett*, Saw and Toothed Cotton Ginning*, pp. 7, 32; Aiken, "Evolution of Cotton Ginning," pp. 199-206;Roper, "Cotton Ginning" pp. 338-39.; Ballard and Doyle, "Cotton-Seed Mixing Increased by Modern Gin Equipment*",*.

[13] U.S. Bureau of Plant Industry, Soils, and Agricultural Engineering, *Better Cottons*, pp. 955-58; Doyle, Meloy and Stine, "Cotton," p. 400. According to Cook most farmers only brought one or two bales to the gin at a time, which magnified the problem of the intermingling of seed. Cook, "One-Variety Cotton," p. 13. Cook, "Local Adjustment," p. 41, thought that the two sources of contamination were roughly of equal importance.

[14] U.S. Congress, *Hearings*, 80th Cong., 1st Sess., Part 2, October 10, 1947, p. 957.

Thus, "the farmer as an individual finds himself practically powerless when he attempts to establish and maintain a pure stock of cotton."[15]

In this environment new cotton varieties proliferated but soon lost their distinctive advantages under mass cultivation. As Ware put it, a "very high percentage" of the varieties "come and go within a rather brief period."[16] Almost every contemporary authority highlighted the rapid turnover in varieties under cultivation. Of the 58 varieties reported in the Tenth Census (1880), "only 6 were commonly in cultivation in 1895," and none were grown by the mid-1930s. Of the 118 varieties Tracy listed in 1895, only 2 were still present in 1925; and of the 600 varieties Tyler enumerated in 1907, fewer than 25 were in existence in 1925 and "only 9 were cultivated extensively." The problem was that "much of the benefit gained by bringing in new varieties and by the excellent breeding work that was done by the Department of Agriculture, private breeders, and the State experiment stations, has been lost by the failure to perpetuate the best strains and varieties and to keep them free from admixture with inferior kinds."[17]

There are numerous accounts of promising varieties being destroyed by cross-pollination and mixing at the gin. As a prominent example, in 1912 Roland M. Meade first selected a prized variety in fields around Clarkville, Texas. This variety (Meade) had lint of over 1 1/2 inches and had black seeds that were practically devoid of fuzz. The seed was taken to the Sea Island areas of South Carolina, increased, and sold in that region. There it produced a staple length averaging 1 5/8 inches and showed exceptional uniformity. "Meade was on the way to becoming a striking success. More than 10,000 acres were grown between 1920 and 1922, but mixing of seed and planting in close proximity to fuzzy-seeded upland varieties resulted in a rapid contamination in the stocks, the mixed fiber was rejected by the trade, and the variety was largely abandoned after 1925."[18] Cross-pollination and the mixture of seed at the gin reduced the ability of farmers who used saved seed to cultivate high-yielding, high-quality varieties.[19] Purchasing commercial seed was an expensive proposition: data from the

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[15] Doyle, "Cotton," p. 264.

[16] Ware, "Plant Breeding," p. 712.

[17] Ware, "Plant Breeding," p. 696.

[18] Ware, "Plant Breeding," pp. 690-91. The literature repeatedly emphasized that mills would prefer shorter but uniform fibers to fibers of different lengths.

[19] There are several forces affecting seed quality. For example, if farmers chose their seed stock from a random sample from the gin, it would have the negative effect of selecting strains with high seed-to-lint ratio.

early 1920s indicate that the commercial product cost 2.5 to 4 times as much as "gin-run" seed, and that improved seed sold by breeders cost 6 to 8 times as much.[20]

Coupled with these production externalities were serious marketing imperfections. According to the preponderance of testimony and in line with the observed pattern of falling staple lengths and stagnating yields, local markets in the South failed to provide sufficient rewards for producing higher quality cotton.[21] Complaints about middlemen seem to be common to all agricultural commodities, but in this case, the criticisms went beyond the habitual grousing. The cotton grading and marketing system in place at the turn of the century was one of the most complicated and controversial aspects of the whole cotton production process.[22] Accurately grading individual bales of cotton in local markets was prohibitively expensive, given the technology of the day. The use of mixed or gin-run seed added complications because there would be "considerable variation in quality and length of lint" within a single bale, making a small sample drawn from the exterior less representative.[23] As a result the use of pooling contracts was widespread; cotton was generally sold in small local markets on the "hog-round" or "on point" system, meaning buyers graded a sample of bales and then paid one average price for all the cotton in that market.[24] The cotton would then be shipped to regional markets where highly trained specialists would grade a sample from each bale in special rooms with proper lighting, temperature, and humidity. After grading the cotton would be assembled in larger running lots of roughly similar quality

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[20] The ordinary ratios are based on data for 1920-22 from USDA, "Cotton Seed," pp. 49, 59. The improved seed ratios are based on prices found in Coker's Pedigreed Seed Company catalogs. For examples see the price list dated February 1, 1918, inserted in *Coker's, Spring 1918*, and the *Coker's, Spring 1927*, pp. 14-29. In 1927 new releases cost farmers about $3.00 a bushel of 30 pounds plus shipping charges. In addition to the reasons offered above, southern poverty, tenancy, low investments in education and extension activities, and high interest rates may have discouraged investments in better seed.

[21] Cook, "One-Variety Cotton," pp. 12, 36; Cook and Martin, *Community,* p. 4; Crawford, "Point Buying," pp. 376-86.

[22] Virts, "Efficiency," pp. 390-91.

[23] Darst, "Cotton-Seed," pp. 190-91.

[24] "This [the hog-round] system did not provide for the paying of fair premiums for better cotton, prices being based on the average quality produced in each district, usually with no advantage to the farmers who planted better varieties." Cook and Doyle, "One-Variety Community," p. 132. The practice of pooling cotton in local markets was not a short-lived phenomenon. Elsewhere Cook noted that, "'the practice is old and longstanding, so that nobody now alive can be blamed for starting it.'" As quoted in Coruthers, "One-Variety Cotton," p. 13.

As is often true, the nomenclature used to describe the cotton market varies between authors. For example, Garside used the term "hog-round" system to describe the practice of quoting a single, average price for a large number of bales and "on point" pricing for the practice of quoting a single price for all of the cotton in a given market on a given day. Garside, *Cotton*, p. 179. Others use "round lot" pricing to describe the first practice and "hog-round" pricing for the second. Note that making an all-or-nothing offer to an individual seller to buy a number of bales at a price based on average quality can preserve quality incentives.

bales for sale to the cotton mills. There was a regional division of labor among mills, with some demanding better grades of cotton and producing higher quality output than others.[25] Once a given mill had adjusted its machinery it required a uniform staple length to run efficiently. A difference of 1/32 of an inch could be significant to mills. The workings of the hog-round system encouraged farmers to "free ride" by marketing lower quality cotton than their neighbors, and helps explain the rising importance of short-staple varieties such as "Half-and-Half." Ordinarily one would expect pooling contracts to break down, as individuals who produced higher-quality goods demanded a higher price. As predicted, some plantation owners did sell directly in central markets where the crop could be graded separately.[26] But most tenants and small farm operators lacked the economies of scale, information, and perhaps savvy to mitigate the problem. Such farmers suffered from problems of unequal bargaining power and asymmetric information as they likely confronted only one or perhaps two buyers in local markets. For these reasons, most contemporary accounts argued that high-quality cotton varieties were being driven from the market, exactly as Akerlof's "lemon model" would suggest.[27]

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[25] Wright, *Old South*, pp. 133-35.

[26] Virts, "Efficiency," pp. 390-93. Nancy Virts argued that these general marketing problems help explain the persistence of the plantation system. She noted that plantations on average produced higher quality cotton and that this could be due to their having economies of scale in marketing that allowed them to bypass local markets. She does not test among other hypotheses such as that plantations occupied better land that was more suitable for producing longer staple varieties. Although Virts accepted the argument that buyers in local markets generally offered one price for all, she did not emphasize the dynamic implications of this system on cotton quality. *Ibid*., pp. 387-88. In addition to Virts's observations about cotton marketing, plantations also provided a form of vertical integration and scale economies that protected seed quality by reducing cross pollination and seed mixing problems. For example, America's largest plantation, Delta and Pine Land Company, generally grew only one commercial variety at a time. When other varieties were grown commercially or as part of the seed-breeding program, the company was meticulous in separating different varieties in the field and at the gin. For this reason, plantations represented a market solution to the externality problems, which begs the question why the land in plantations was declining. Edmonds, "Around the Clock," pp. 40-43, 80. Burges observed that only shipments of 100 bales or more could command special treatment with respect to quality. Burges, "Break This Vicious Circle," pp. 5, 6, 29

[27] Akerlof, "Market," pp. 488-500.

TESTING FOR MARKET FAILURE

Although the "lemons problem" is much discussed, important real-world examples are rare in the literature. Thus the nearly unanimous testimony of cotton specialists asserting that grading and marketing problems seriously distorted production incentives should be of considerable interest. The USDA and various state agencies conducted numerous detailed studies investigating the relationship between price and quality in local and regional markets across the South. Studies of local markets in Arkansas (1913-16), North Carolina (1914-16), Texas (1926), Alabama (1926 and 1927), and South Carolina (1925-27) all found prices varied little with quality.[28] The two most definitive studies on cotton pricing were published by the USDA in 1936 and 1939. Howell and Burgess (1936) monitored individual transactions in over 100 local markets between 1928 and 1933, and independently classed 300,000 bales of cotton. They compared the prices received in local markets for cotton of a given quality with those prevailing in central markets for the same quality on the same day. (Neither buyers nor sellers in the local markets knew the results of Howell and Burgess's classifications at the time of sale.) The survey found that the local market price differentials for various staple lengths were far smaller than the differentials in the central markets (which better reflected the value cotton spinners placed on cotton). As an example, the Howell and Burgess research team classified and recorded the prices of over 100,000 bales of Middling White cotton. Panel 1 of Table 2 offers a summary measure of the price differentials by staple length prevailing in the local and central markets over the 1928-33 period. "For the 5-year period, on an average, premiums for staples longer than 7/8 inch in local markets amounted to only 17 percent of those in central markets and varied from only 12 percent for 15/16-inch cotton to 34 percent for 1 1/8-inch cotton. At the other end of the spectrum, discounts for cotton shorter than 7/8 inch in local markets amounted to only 6 percent of those quoted in central markets for cotton with a staple length of 13/16 inch."[29] The summary conclusion is that the price signals given to farmers in local markets systematically failed to reflect the incentive structure being generated in central markets.

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[28] As reported in Howell and Burgess, *Farm Prices*, pp. 2-3.
[29] *Ibid*., p. 21.

Farmers who sold short-staple cotton were vastly overpaid, and those who marketed longer staples were shortchanged.[30]

Howell and Watson's (1939) study covering the 1933-36 period took the research a step further.[31] In addition to comparing local and central markets, they compared local markets offering impartial public classification services (PCS) with those lacking such services.[32] Panel 2 of Table 2 shows the differentials by staple length for bales sold in the two types of local markets compared with equal quality cotton sold on the same day in the central markets. (Note that the timing of sales in the local markets with PCS and those without PCS differed, making it necessary to report two series for central market differentials.) Howell and Watson found that the quality differentials in the central markets were more closely reflected in local markets with public classification services than in those without such services.[33] As an example, the local markets with public classers captured 56 percent of the central market premiums for cotton of 1 1/16 inch (relative to 7/8 inch) whereas markets without public classers captured only 30 percent. Compared with the 1928-32 period, farmers selling in both types of markets were increasingly receiving greater quality differentials, especially at the higher end.[34]

Several natural experiments offer further evidence on the workings of local markets. In 1923 the cotton farmers in the McKinney area of Collin County, Texas began the process of forming one-variety communities (see p. 9) to improve cotton quality and yields. Buyers soon recognized that the McKinney market had better cotton and began to offer substantial premiums compared to prices offered in nearby markets.

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[30] Numerous critics asserted that local cotton graders systematically cheated small farmers. This may have happened, but Howell and Burgess's findings suggest that the misgrading at the local level hurt some farmers and helped others. For a statement of the cheating hypothesis see the testimony of Representative Hampton P. Fulmer in U.S. Congress, *Hearings,* 67th Cong., 4th Sess., Part 1, February 5, 9, & 12, 1928, pp. 1-5.

[31] Howell and Watson, *Cotton Prices*, pp. 1-54.

[32] One might be concerned that the availability of these services are not random and thus the comparisons did not represent true natural experiments. For example, more advanced areas might have more access to classification services, better markets before their spread, and higher overall quality. Internal evidence suggests that if anything the biases ran in the opposite direction. Although the differentials were greater in markets with public classification services, average prices and quality were not higher than in markets without such services. The availability of such services may have been too recent to have much effect on cotton improvement.

[33] They also found that price variability, conditional on quality, was lower in markets with public classification services.

[34] The finding that cotton markets were improving over the interwar period is consistent with the informed observations of Alston Hill Garside, an economist at the New York Cotton Exchange. Garside credited the advent of uniform federal grading standards with improving grading practices. Garside, *Cotton*, pp. 176-84.

"Difficulty then arose because the higher prices at McKinney soon attracted farmers from other communities, who soon were hauling considerable quantities of inferior cotton to McKinney, in order to take advantage of the higher prices paid there.
One farmer was known to have hauled 48 bales of cotton 150 miles by truck and to have sold it for $5 per bale net above what he was offered on his local market."[35] As outsiders began shipping to McKinney, its share of the region's market to jump from 25 percent in 1925 to 37 percent by 1928. This behavior only made sense where the hog-round system was being employed. Predictably, the McKinney price fell and the one-variety effort collapsed.[36]

Other areas had long held a reputation for producing quality cotton and traditionally received price premiums. Some mills and even the Liverpool Market essentially "bought cotton on the basis of place of origin, as well as on grade and staple length."[37] The appearance of trucks and good roads eroded these advantages. As an example,

> Country buyers of cotton knew the value placed on the Hope, Arkansas warehouse tag. They went into the sand hill sections of South Arkansas, bought short cotton hog round, trucked it over the concrete highway to Hope, put a Hope compress tag on it, and shipped it as Hope cotton.… When the spinner got hold of the cotton he had a real surprise coming. It was not Hope cotton. It was some inferior short stuff from the sand hill of South Arkansas. So the premium went off Hope cotton. Similar situations prevailed throughout the South.[38]

Collectively, these experiences with free riders dumping inferior cotton into quality markets, coupled with the exceptionally detailed and careful studies on local and central market pricing and grading practices, strongly support the assertions of contemporary cotton specialists. The hog-round system was, indeed, widespread, and it resulted in a "lemons problem" that led to a decline in cotton quality.

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[35] Saunders, *Pioneer*, p. 7.
[36] *Ibid*., pp. 1-10. The same general story was repeated across the South, as early one-variety community programs suffered because outsiders shipped in inferior cotton. Coruthers refers to similar cases in North Carolina, Oklahoma, and Mississippi. Coruthers, "One-Variety Cotton," pp. 39-55.
[37] Pike, "Cottonseed," p. 2; Crawford, "Point Buying," pp. 376-86.
[38] Andrews, "Cotton," pp. 8-9; also see Garside, *Cotton*, p. 181.

THE ONE-VARIETY COMMUNITY MOVEMENT

Early in the twentieth century USDA scientists intensified their breeding and extension projects aimed at improving the yields and quality of U.S. cotton. Initially, these efforts paralleled similar campaigns for other crops.[39] Because of the problems discussed above, researchers soon realized that it would not be sufficient to just develop and distribute small quantities of better seeds. Rather their campaign would have to change the complex institutional structure in order to reduce negative externalities and better align local prices with those in regional markets. According to the father of the one-variety community movement, O. F. Cook, "the method of distribution that was first projected did not result in establishing commercial supplies of pure seed. Several of the varieties that were developed and distributed in the early years of the cotton-breeding work were lost completely before the system of distribution was changed."[40] To counter these problems, Cook developed an ambitious program to develop better cotton varieties, improve cultural methods, standardize cotton classification systems, advance new seed treatment processes, and train cotton qualified graders.[41]

At the heart of the program was a utopian scheme to fundamentally change the way cotton was grown, ginned, graded, and marketed in the United States. To succeed would require a "new association of ideas" to alter how farmers thought about their community.[42] Instead of each individual farmer choosing his own variety, the new system would be built on a cooperative structure in which cotton farmers would organize "one-variety communities." The USDA in conjunction with state authorities would provide education, guidance, and standardized contracts. Cook and his fellow reformers envisioned communities ranging in size from a group of farmers using one gin to encompassing an entire state. In addition to producing, ginning, and marketing only one variety of cotton, the communities would be responsible for increasing (and in some cases breeding) pure seed for their members. It is important to note that from the outset the literature on one-variety communities emphasized the benefits to the nearly

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[39] For an example of these efforts in the wheat industry see Olmstead and Rhode, "Red Queen," pp. 8-20.

[40] Cook, "One-Variety Cotton," p. 8.

[41] By the mid-1930s, the USDA had initiated genetic and breeding research programs in every important cotton producing state. Ware, "Plant Breeding," p. 665.

[42] Cook, "One-Variety Cotton," p. 33.

total exclusion of any discussion of the costs associated with individual farmers losing the freedom to tailor their cultural practices to fit their particular growing situations.[43]

Cook first suggested the idea of one-variety communities in 1909 and subsequently developed the concept in an article published in 1911.[44] At first the USDA concentrated its one-variety campaign in the newly irrigated cotton regions in the Far West, promoting the idea in conjunction with the distribution of a number of recently introduced or developed long and medium staple varieties. Often local USDA scientists withheld the distribution of the new seed until a one-variety structure was in place. The first one-variety community began in 1912 with the distribution of Yuma cotton in the Salt River Valley of Arizona.[45] At about the same time Durango was grown in a single-variety community in the Imperial Valley of California. After 1920 Acala, which the USDA had introduced from Mexico in 1907, became an important one-variety cotton in many western areas.[46] The initial efforts were often loosely structured. As an example, to gain access to Acala seed, growers in Riverside County organized the Acala Cotton Growers' Association of the Coachella Valley in 1920. By 1923 the region's farmers had voluntarily planted Acala on over 96 percent of their cotton acreage. It was only after the fact, in order to prevent the mixing of seeds at gins and cross-pollination, that Riverside County gave legal protection to the district in 1924 by passing an ordinance declaring the county a pure seed district.[47] These western initiatives, as well as scattered efforts in some southern states, generally met with mixed results as farmers and USDA officials experimented with varieties and structures. Most one-variety districts reported higher yields and increased premiums, but for a number of reasons (including problems of free riding from nearby farmers and inadequate supplies of the one-variety seed to serve a given area) many of the early districts were short-lived.[48]

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[43] Even the few one-variety proponents who addressed this concern typically argued that under the prevailing adverse conditions each farmer stood to gain from adopting the community's improved seed. Willis, *One-Variety Cotton*, pp. 3-4.

[44] Cook, "Cotton Improvement," pp. 397-410; Cook, "Local Adjustment," p. 41.

[45] The North Carolina Agricultural Experiment Station began work on community production around 1915, but it is not clear if any communities were actually formed at that time. Coruthers, "One-Variety Cotton," pp. 75.79.

[46] Ware, "Plant Breeding," p. 697; after Acala was introduced it took researchers several years to select and develop outstanding strains suitable for commercial use. *Ibid*., p. 689. Durango was another recent Mexican introduction and Yuma and Pima were the product of USDA breeding programs in the Southwest and depended largely on the on crosses of Egyptian cultivars with Sea Island cotton.

[47] McKeever, "Community," p. 29.

[48] For inadequate supplies of planting seed, see Coruthers, "One-Variety Cotton," p. 112.

A giant step in the one-variety campaign occurred in May 1925 when California enacted legislation declaring eight San Joaquin Valley counties and Riverside County as a one-variety community. The new law represented the culmination of an extended lobbying effort by W. B. Camp, the USDA's California cotton specialist who had been sent west in 1917 to promote one-variety production of high-quality varieties. The law, along with the institutional structure that evolved in 1926, would define the development of the state's cotton industry for the next six decades. The law stipulated that only Acala could be planted, harvested, or ginned in a district of well over four million acres. Even the possession of non-Acala seeds was illegal (except at a few research stations).[49] The USDA's Cotton Research Center at Shafter became the *de facto* sole Acala breeder in the state, as the USDA successfully strove to keep private seed breeders out of the Central Valley. Under this system, Shafter's "head breeder" held enormous power, overseeing a research program that for the next 60 years would be the only source for cottonseed for most of California. To increase and market the seed bred at Shafter, growers organized the California Planting Cotton Seed Distributors in 1926. Most specialized accounts credit the one-variety system with contributing significantly to California's high cotton yields, which over much of the twentieth century were roughly double the national average. (In fact, many factors such as climate and irrigation contributed to the state's yield advantage.) These accounts also credit the one-variety community with helping California growers earn quality premiums for their relatively uniform, medium staple product.

To date, neither the economics nor history literature has devoted much attention to the one-variety movement. The one exception is John Constantine, Julian Alston, and Vincent Smith's critical *Journal of Political Economy* article analyzing the California one-variety law.[50] They argued that in the 1970s and 1980s the legislation artificially limited California's production, resulting in higher prices for the state's cotton.[51] Landowners in regions most suitable for Acala production (the community variety) benefited, while other Central Valley farmers experienced yield losses or abandoned cotton. Constantine, et al. concluded that the legislation became

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[49] In 1941 Riverside County dropped out of the program in order to grow longer staple Pima cotton, which fetched relatively high prices during World War II. This move posed little threat to Acala growers, because of the physical separation between Riverside County and the San Joaquin Valley.

[50] Constantine, Alston, and Smith, "Economic Impacts," pp. 951-74.

[51] It is important to emphasize that Constantine, Alston, and Smith argue that the technological regulation became increasingly costly as time passed and was clearly inefficient by the 1970's. They are agnostic as to whether or not the law was efficient in its early decades.

increasingly inefficient and by the late 1970s cost growers as a group about $180 million annually (over 10 percent of the annual value of the state's cotton output). The law remained in force because a faction of California farmers who benefited from the legislation had captured the system's administrative apparatus.[52]

Constantine, et al. provide a valuable perspective on the relatively recent history of the California one-variety law, but they say little about the early history of the state's experience, and they ignore a far larger, but more short-lived, southern one-variety movement. Understanding the movement outside of California not only provides a fresh perspective on the sources of southern development, but also helps in evaluating the one-variety legislation in California.[53]

Although there were fits and starts in the one-variety movement in the traditional Cotton South dating back to the World War I era, there were few lasting accomplishments. But the USDA intensified its efforts, initiating one-variety campaigns throughout the South in 1931/32. These were often tied with education and other cotton improvement programs. Almost all early studies reported immediate increases in yields and in quality in one-variety programs and most reported at least modest financial returns to farmers.[54]

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[52] Constantine, Alston, and Smith, "Economic Impacts," pp. 951-74. Constantine, Alston, and Smith were not alone in noting that the need for different varieties on different soils could be a major problem for the one-variety concept. Campbell's studies reported that Oklahoma farmers were concerned about yield losses due to the inability to fine tune varieties to local conditions. He also noted that although one-variety communities increased the standardization of the product, there was still considerable variance within a one-variety community so that the bales had to be resorted as with non-one-variety community production. Campbell, "One-Variety Cotton," pp. 5-19; Campbell, "Comparisons," pp. 7-33. Other critics of one-variety communities raised the fear that widespread standardization of varieties might expose farmers to catastrophic losses should a new disease appear for which the standardized variety lacked resistance. K. S. Quisenberry, "The Role of Public and Private Agencies in Cotton Improvement," pp. 1-8, Dallas TX, Feb. 2, 1954, Delta and Pine Land Company Records, Box XV, Miscellaneous, Joint Cotton Breeders Policy Committee file (2/8), 1953-54 in Special Collections, Mitchell Memorial Library, Mississippi State University. Hereafter other sources from this collection cited as D&PL archives.

[53] Even other Acala growing states differed. For example, the one-variety movement started in the Rio Grande and Pecos River areas of New Mexico in 1922. There was no statewide one-variety legislation, but by the early 1930s Acala constituted more than 95 percent of the cotton grown in the state. As in California the foundation seed was supplied by the USDA, a system of inspection and certification was developed for the farms that increased the seed, and local gins developed special precautions when ginning planting seed. Between 1922 and 1932 the state's yields increased from 201 to 412 pounds of lint per acre (roughly on par with what occurred in California), with local observers giving most of the credit to the community production system with its pure seed program. Coruthers, "One-Variety Cotton," pp. 106-108; Leding, "Community," pp. 1-23; USDA, *Statistics on Cotton*, p. 82.

[54] U.S. Congress, *Hearings*, 67th Cong., 4th Sess., Part 1, February 5, 9, & 12, 1928, p. 135. The two exceptions appear to have occurred in Florida and Oklahoma. In Florida farmers evidently made a poor choice of varieties. In Oklahoma studies reported significant quality increases and in 1932-33 estimated added revenue of about $2.31 per bale. But in 1933-34 the estimated added benefit to one-variety production fell to a mere $0.33 per bale. Ballinger and McWhorter, "Results," pp. 68-71. See Porter, "Toward Standardized Cotton," pp. 21-22.

The movement started in Georgia in 1931. By the end of 1934, there were 45 communities in various stages of development and preliminary work was underway in starting 25 others. The one-variety producers were immediately rewarded with higher yields, along with quality and length premiums valued at about $7.13 an acre.[55] In Oklahoma the one-variety movement began in earnest in 1932. By early 1933 there were 6 communities with over 25,000 acres and 11,000 farmers participating.[56] In Mississippi, 14 communities were organized in 1931, with the number growing to 33 in 1932; six of these were countywide organizations. By 1937 there were 197 communities in the state, receiving an estimated average increase in revenue (stemming from increased yields and premiums) of $8.71 per acre for one-variety producers.[57] A similar transformation of cotton production was taking place across the South during the 1930s.

From the humble beginnings in the 1930s, the movement took off. Table 3 pieces together key indices of the extent of the one-variety movement for the years 1934-1949. By 1946 there were about 2,275 one-variety communities, producing roughly one half of the entire cotton output of the United States. Table 4 provides data on the distribution of one-variety production across the various states. These data clearly indicate that California was not alone in one-variety production. In fact, in 1946 California accounted for less than 2 percent of the community members, less than 5 percent of the acreage in one-variety communities, and about 10 percent of community output in the United States. California was different because of the size of the participating farms and the legal rigidity of the system, not because its farmers were banding together ostensibly to overcome negative externalities and to capture economies of scale in grading, information, and marketing.[58]

A clearer image of the micro-structure and daily operations of the southern one-variety communities may be distilled from numerous descriptions in experiment station and cotton trade publications. The organizing effort was typically initiated by a small group of local farmers working with the county extension agent, who would call a meeting and provide a set of suggested standardized bylaws. The proposed "Cotton

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[55] Coruthers, "One-Variety Cotton," pp. 67-72; Westbrook, "One-Variety Community," pp. 3-8; and Bledsoe and Westbrook, "History," pp. 16-19. The $7.13 estimate comes from Bledsoe and Westbrook.

[56] Coruthers, "One-Variety Cotton," pp. 80-88. Coruthers gives the membership and acreage for only 5 of the 6 communities.

[57] Willis, *One Variety Cotton*, pp. 1-2; Coruthers, "One-Variety Cotton," pp. 60-63.

[58] According to E. C. Westbrook, in 1956 all one-variety communities were voluntary except in California. Westbrook, "One-Variety Cotton," p. 17.

Improvement Association" was to be established as a non-profit, unincorporated cooperative association. Membership was voluntary and involved no fees or dues. Under some bylaws, membership was "open to any cotton grower" who agreed to the one-variety regulations; in others, new members were admitted with the approval of existing members. Conditions for exit also varied. In some agreements members could withdraw at any time, and those who failed to comply with community rules were automatically dropped without penalty. Other bylaws specified a 5-year membership term. In almost all bylaws the association's membership periodically selected by majority rule (on a one-member one-vote basis) the variety to be grown and elected a small board responsible for the daily operations. The association also formed a relationship with a local gin. If only a fraction of the local growers choose to enter the association, the one-variety community arranged with the ginner to set aside specific days or specific machines to handle members' crop with special care. Thus, the southern one-variety communities were not nearly as compulsory as in the California model.[59]

The community acquired foundation seed from a private breeder (such as D&PL, Stoneville, or Coker) or a state experiment station. A common arrangement was to purchase annually one bushel of foundation seed for each 100 acres of cotton in the community. A small number of selected growers planted this seed in isolated fields, harvested and ginned the resulting seed cotton in a manner to ensure purity, and then exchanged the so-called first-year seed to other members at setprices that were well below the market price of the foundation seed. The other members agreed to plant at least one-tenth of their acreage with this first-year seed, producing sufficient second-year seed for their remaining acreage in the next season.[60] To help maintain purity, all of the cotton grown from the foundation seed was to be ginned under close supervision before any of that grown from the first-year seed, which in turn was ginned before that grown from the second-year seed. The resulting third-year seed was to be sold to the oil mill. As the USDA put it, this plan "provides for a continuous flow of new, pure

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[59] Willis, *One-Variety Cotton;* Westbrook, "One-Variety Community;" Leding, "Community Production;" Wasson, *One Variety Cotton*; Lowery*, Cotton*; and Rains, *Cotton*.

[60] This method of expanding the seed supply represented a large-scale collective implementation of the 1-10-100 technique recommended by extension agents and seed companies (such as Coker's) to individual farmers for maintaining pure seed. *Coker's, Spring 1917*, p. 16. For a detailed guide on how to organize a one-variety community see Bode Hughes, "Organizing Communities," D&PL Company Records, Box XV, Miscellaneous file (2/2) , D&PL archives.

breeder or foundation seed into the community each year and a continuous outflow of old seed to the oil mill."[61]

SMITH-DOXEY CLASSING

During the mid-1930s, the one-variety movement pushed beyond its campaign to restructure cotton production into a more long-lasting effort to reform marketing. Given the prevailing weak market incentives to produce higher quality cotton, farmers in many one-variety communities purportedly began to complain they were not being properly rewarded for their labors. In 1937 President Roosevelt signed the Smith-Doxey Cotton Classing Act that was meant to complement the traditional one-variety communities.[62] The act that went into effect in 1938 made free market news service and cotton classing available to all organized cotton improvement groups. The act was to be largely self-supporting (through the sale of the sample material) and benefit almost everyone up and down the marketing chain except perhaps local buyers-graders. Smith-Doxey classification cards became accepted within the trade, cutting marketing costs by reducing the need to repeatedly re-sample and re-grade cotton bales every time they changed hands. The primary aim of the program was to better align the incentives given to small farmers by narrowing the discrepancies between grading in local and central markets. Under the Smith-Doxey program farmers could mail cotton samples to one of 31 central locations established throughout the Cotton Belt and within a few days receive by return mail a government certified "green card" specifying the cotton's grade, length, etc. There was a catch. To qualify for the free services a farmer had to be a member of an organized cotton improvement group with at least 10 members. These Smith-Doxey districts were typically much less formal than one-variety communities, and in some cases simply represented an agreement between a group of farmers and a ginner to provide special care in handling the group's one variety. The Smith-Doxey districts played no role in breeding, increasing, or marketing seed. A bureaucratic difference was that Smith-Doxey groups were organized out of the USDA Agricultural Marketing Service, whereas the One-Variety Community project was under

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[61] U.S. Congress, *Hearings*, 80th Cong., 1st Sess., Part 2, October 10, 1947, p. 960.

[62] U.S. Congress, *Authorizing the Secretary*, 75th Cong, 1st Sess., Report No. 143, February 24, 1937, pp. 1-3, and U.S. Congress, Letter, 75th Cong., 1st Sess., Vol 81, Part 3, p. 3164.

the aegis of the Bureau of Plant Industry, Soils, and Agricultural Engineering. On the ground, both programs were administered by the cooperative extension service.[63]

A pair of USDA belt-wide surveys on classification practices and the availability of information in the 1935-36 and 1947-48 crop years provide some sense of the changes wrought by the Smith-Doxey Act. The first survey, conducted by John W. Wright, revealed just how poorly informed many growers were when they sold their cotton before the act.[64] This survey of 101 local markets found that 36 percent of growers sold their cotton with no information about general market prices except their price offer, and that 60 percent of growers (accounting for 60 percent of the crop) sold their cotton without knowing its grade or staple length. Even when growers reported knowledge of their cotton's quality at the time of sale, the most common source of this information was the buyer (29 percent of cotton). Less than 10 percent of cotton was classified by impartial parties—the USDA, licensed classers, warehousemen, factors, or ginners.[65] Dissatisfaction with poor information purportedly was widespread. Nearly six-tenths of cotton growers reported a willingness to maintain a self-supporting sampling service to provide official classification. Most ginners surveyed (84 percent) also favored such a service. By way of contrast, most first-buyers disliked the idea and reported a disinclination to base their purchases on official classes. The market situation illustrated in this report, especially the weak bargaining position of growers in local cotton markets, created pressures for reform.[66]

The 1947 follow-up study revealed substantial improvements in price and quality information available to growers since 1935.[67] In the 1947-48 crop year only about 25 percent of growers, who accounted for about 15 percent of U.S. cotton output, sold without having independent information about general cotton prices. Only 45 percent of growers (with 30 percent of the cotton) sold their crop without knowing its quality (again down from the 60 percent of producers and output in the 1935-36

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[63] Betts, "Green Card," pp. 13-16; USDA, "Report of the Chief," pp. 36-39.

[64] Wright, Marketing Practices.

[65] *Ibid*., pp. 20-23. Besides surveying growers, the study also queried first-buyers regarding their practices. These buyers reported relatively little cotton—only 11 percent—was purchased without any effort to classify the cotton in individual bales. The author expressed skepticism, however, about the thoroughness of the first-buyers' own classification efforts. Only one-third of first buyers owned or had access to a copy of the official cotton standards. *Ibid*., pp. 29-30. The problems associated with imperfect information about quality obviously were not limited to cotton, and during the first half of the 20th century the USDA established standards for grading most agricultural products. Given the technology of the time, classing cotton was probably more difficult than grading most major crops.

[66] *Ibid.*, pp. 60-62.

[67] Soxman, *Marketing*. This study covered 98 of 101 local markets analyzed in the 1935-36 study.

season). In 1947-48 growers with impartially provided quality information sold 52 percent of the cotton crop, up from just 9 percent of the crop in 1935-36. The spread of the Smith-Doxey system accounted for much of the change. In 1947-48, 40 percent of the crop in the markets studied received green cards (Form 1 classifications) by the time of sale.[68] The study concluded that in 1947 growers "generally occupied a stronger bargaining position than in 1935" when "most growers reported knowing neither the market price nor the quality of their cotton at the time of sale."[69]

The Smith-Doxey program apparently went a long way to correcting the problems highlighted in the cotton pricing studies of the 1920s and 1930s. For example, based on a survey that recorded the pricing of about 300,000 bales of cotton in 24 local markets across the cotton-belt over the 1951-52 to 1953-53 seasons, William Faught concluded that:

> prices to growers in markets where cotton is sold on the basis of Smith-Doxey cards … reflected central market differentials for grade and staple rather fully and accurately. In markets where growers did not have or did not use reliable quality information in the sale of their cotton, local prices reflected little, if any, of the central market differentials.[70]

In local markets where most "cotton was sold on the basis of Smith-Doxey cards" the price reflected, on average, 78 percent of central market differentials whereas in local markets where "cotton quality information was not readily available to growers" the price reflected only 3 percent of differentials.[71] As officials at the Texas agricultural

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[68] *Ibid*., pp. 12, 69. The use of the Smith-Doxey system was unevenly distributed across the cotton belt and over farms of different sizes. Virtually all cotton growers in Arizona, California, and New Mexico received Form 1 classing, as did about one-half of the growers in Arkansas, Oklahoma, and Texas, and one-quarter of the growers in Alabama, Georgia, and Mississippi., *Ibid*., p. 16. Larger growers were far more likely than smaller farmers to sell on the basis of Form 1 classification, *Ibid.*, pp. 12, 16, 62, 69. Many buyers expressed an unwillingness to use the government classification system.

A study conducted in the same crop year by Southern Regional Cotton Marketing Project comparing the behaviors of participants and non-participants in one-variety communities found that, except in the high plains, participants were far more likely to use USDA classification services. Faught, et al., *Cotton*, p. 28.

[69] Soxman, *Marketing*, pp. 2, 69.

[70] Faught, *Cotton Price*, p. 3. Faught noted that farmers who were enrolled in the Smith-Doxey service but did not use the green card at the time of sale frequently did not receive full central market differentials. Often these farmers sold their cotton so quickly after ginning that the government classification information was not yet available. *Ibid*., p. 22.

[71] *Ibid*., pp. 14-15 and 26-27. As is often the case in the American federal system, experiments initiated by individual states subsequently provide a model for national programs. This appears to have been the case with the Smith-Doxey classification system. In the early 1920s, at the urging of local Farm Bureaus, the California State Department of Agriculture began a public classing service. In addition, farmers in some areas organized selling agencies to handle bulk sales. The combination of these programs resulted in a price premium of "1½ to 3 cents a pound over that [cotton] of similar grade sold independently in the local yard on the same day." The fact that California Farm Bureau members, who in the main would have been relatively educated and informed producers, requested and benefited from such a program suggests that the benefits for most southern producers could have been substantial.

extension service put it: "Smith-Doxey has probably done more than anything else to breach the traditional system of hog 'round buying."[72]

As a result of the advantages of the Smith-Doxey program, participation rapidly increased. Table 5 provides summary data of the growth of the program between 1938 and 1952. By 1951 about 65 percent of American cotton was being graded under this system. The diffusion of this new organizational form proceeded at a pace rivaling the era's better known mechanical and biological technologies. In the 1954 season just under three-quarters of the U.S. crop was classified under the program. And from the mid-1960s to the present, Smith-Doxey cotton represented roughly 95 percent of the crop.[73] In summary, detailed quantitative studies on the diffusion and impact of Smith-Doxey services suggest that the program had a significant impact on narrowing the gap between local and central markets in cotton classing.[74]

THE REVOLUTION IN U.S. COTTON PRODUCTION

There were many quantitative indices of the revolution in U.S. cotton production, including changes in cotton quality and in varietal concentration. Just as the one-variety advocates had planned, there was an almost immediate increase in the staple length in one-variety districts compared to nearby areas. The aggregate data on the length of U.S. cotton reflected these developments. Figure 2 shows that between 1928-33 and 1945-49 the average length of U.S. upland cotton increased by about one-eight of an inch, or four staple lengths. This was accomplished by the systematic substitution of medium-staple varieties for short-staple varieties. The percentage of upland cotton 29/32 of an inch and less fell from over 50 percent in 1928-32 to less than 14 percent in 1944-49. Between 1928-30 and 1946-47 the percent equal to or greater than 1 inch increased from about 22 percent to about 73 percent. Mississippi has traditionally been known for producing high quality cotton.

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[72] Texas A&M College Extension Service, New Agriculture, p. 37.

[73] USDA, Consumer and Marketing Service, Story, n.p.

[74] We do not know the extent of double counting in the data on one-variety communities presented in Table 3 and the Smith-Doxey data shown in Table 5. But from Brown and Ware's account it is likely that many one-variety communities were Smith-Doxey groups, but that Smith-Doxey groups generally were not enumerated as one-variety communities. In addition, Brown and Ware noted that after 1948 Smith-Doxey groups "have taken the place of one-variety communities in many areas, especially in large portions of the main Cotton South." This implies that it is at least possible, even likely, that by 1946 well over 50 percent of U.S. cotton production came from one or the other of these forms of community organizations. Brown and Ware, Cotton, p. 83.

Writing in 1950, J. F. O'Kelly noted that "twenty years ago only 31 per cent of the cotton produced in Mississippi was 1 to 1-1/32 inches. Currently 92 per cent of the State's cotton is in this staple range."[75] At the other end of the scale, cotton less than one inch fell from 45 percent in 1928-30 to about 2 percent of Mississippi's production in 1946-47. Similar progress occurred across the Cotton Belt. As an example, "the South Carolina crop went from an estimated 20 percent cotton stapling 15/16 inch and longer in length in 1926 to over 97 percent of such lengths in 1943. With this increase in length there has also been an increase in per acre yield."[76] A number of factors such as changing cultural practices surely contributed to the change in cotton quality and yields. But the rapidity of the change (with local yield increases and longer staples reported within a couple of years following the introduction of a community), and widespread contemporary testimony point to the one-variety movement as an important catalyst for the changes.[77]

In addition to promoting the production of longer-staple cottons, the one-variety program contributed to a dramatic decline in the number of varieties of cotton grown in the United States. One-variety advocates saw this decline in bio-diversity as a positive step. One of the USDA's initial goals was to significantly reduce the number of varieties, in order to eliminate inferior cottons, to reduce the problems of cross-pollination and gin mixing, and to promote standardization of the resulting product. Nobody really knows how many varieties and strains of cotton were being grown in the American South in 1930.

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[75] O'Kelly, "Cotton," pp. 36-37.

[76] U.S. Congress, Testimony of George J. Wilds, in *Hearings*, 78th Cong., 2nd Sess., December 4-9, 1944, p. 399. Wilds was the president Coker's Pedigreed Seed Company.

[77] For one example attributing the improvements to the one-variety-community movement and of the rapidity of the change see Ware, "Plant Breeding," p. 662. According to most commentators one-variety communities facilitated education campaigns and provided incentives that stimulated the adoption of better cultural methods. See Brown and Ware, *Cotton,* p. 84. Our assessment of the premiums and discounts suggests that the economic significance to farmers of increased fiber length was probably much less than the impact of higher yields. Over the period 1930-60 increasing the staple length by 1/8 of an inch from a base from 7/8 to 1 inch (the rough range that applied to most farmers) generally resulted in a premium of only 5-10 percent. The premiums were non-linear because for increases in length for longer cottons the premiums were much larger. The relatively small premium in the length range applicable to most farmers may represent yet another example of what agricultural economists refer to as the "Cochran Effect," meaning that the benefits of a technological change are largely passed on to consumers. According to O'Kelly, "Cotton," p. 51, "Varieties producing a medium staple length (1 to 1 3/32 inch) have been the favorites for at least two decades. In many of the Cotton Belt states 75 to 95 per cent of the cotton produced is in this length range. This fact has considerably reduced the discounts in the markets for lengths just shorter than one inch and has greatly increased the premiums paid for lengths 1 1/8 inches and longer."

In 1907 Tyler listed over 600 varieties, and given the tendency for the number to increase due to mutations and cross-pollination, it is likely that substantially more existed at the dawn of the one-variety movement. Westbrook claimed that there were about 300 varieties being grown in Georgia alone in 1930.[78] Many of these so-called varieties were undoubtedly just different local names for the same variety, but the exact number is not so important as the general magnitude in relation to what existed after the one-variety movement picked up steam. With rare exceptions, such as the Acala communities in the West, no single variety dominated a given region or state in 1930. This situation changed rapidly.

In 1954 only 10 varietal types (a variety such as Acala had several strains) accounted for over 77 percent of the cotton grown in the United States, and 5 pure varieties accounted for almost 52 percent of the nation's crop. A single variety (Deltapine 15) made up 25.5 percent of all U.S. cotton acreage.[79] Contemporaries credited the one-variety campaign with playing a major role in causing the concentration of varieties. As an example, according to the 1947 Congressional hearings on cotton quality "the one-variety program has reduced the number of varieties grown and standardized the entire crop of the organized areas on a few improved high-yielding varieties."[80] Brown and Ware were equally emphatic: "The cotton-varietal-standardization movement...has practically made over the situation in cotton varieties in America and has thereby contributed greatly to quality improvement of cotton."[81]

State-level data offer a clearer sense of the movement toward varietal concentration, because by the early 1950s several states had effectively become *de facto* one or two variety enclaves (see Table 6). These enclaves transcended state boundaries; as an example, Coker 100 Wilt comprised over 95 percent of the cotton grown in South Carolina, North Carolina, and Virginia. In many states the extent of *de facto* one-variety production far exceeded the production of official one-variety communities. Even in states with a greater number of varieties, such as Texas, a given region likely

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[78] Westbrook, "One-Variety Cotton," p. 16. Westbrook's assertion that 1200 varieties had been grown in the United States in 1930 is probably a misreading of Ware. A 1947 Congressional report on cotton asserted that before the one-variety cotton movement over 500 were grown. U.S. Congress, *Hearings*, 80th Cong., 1st Sess., Part 2, October 10, 1947, p. 955.

[79] Brown and Ware, *Cotton*, p. 97.

[80] U.S. Congress, *Hearings*, 80th Cong., 1st Sess., Part 2, October 10, 1947, p. 960. With the introduction of one-variety communities the decline in the number of varieties happened fairly rapidly in local areas. As an example, the county agent for Carroll County, Georgia, reported that between 1933 and 1937 the land in one variety went from a few acres to 25,000 acres and the number of varieties grown in the county had dropped in half. Wiley, "Cotton," pp. 46-47.

[81] Brown and Ware, Cotton, p. 98.

had a high concentration of a specific commercial variety whether or not there was a formal association of farmers.[82] In 1952, 35 percent of U.S. cotton was ginned in counties where one variety comprised 90 percent or more of acreage, and 46 percent came from counties where one variety accounted for 75 percent of the acreage.[83]

Across the South local studies reported net benefits to one-variety community members similar to those we reported above (p. 14). In addition, USDA scientists generated a number of more global estimates. In 1943 the Bureau of Plant Industry, Soils and Agricultural Engineering estimated that one-variety producers were receiving an additional return of $7.50 an acre. In 1945, C. B. Doyle reported a benefit of about $7.00 an acre to participating growers. He further reported that the USDA had invested $800,000 from 1911 through 1944 in creating the one-variety community system, and that this investment had generated an annual return in excess of $56,000,000 in 1944 alone. In 1950 the USDA estimated that one-variety communities had generated an increased value to growers in the "old belt" over the 1938-1945 period of $260 million. The USDA reported cumulative expenditures on one-variety community development up to and including 1945 of less than one million dollars.[84] In its presentations to Congress during the late 1930s and early 1940s, the USDA showcased the one-variety movement as one of its high profile programs, consistently reporting annual net benefits to participants in the range of $5 to $7 per acre.[85] This compares with an average value of cotton lint of $33.90 per acre over the 1935-44 period.[86]

Another important indicator that the one-variety movement contributed to the revolution in cotton production is the widespread support it received beyond the USDA, Extension Service, and grower communities. Representatives of the cotton textile

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[82] The High Plains region of Texas and Oklahoma has been an outlier, following a different path of technological development from the rest of the Cotton South and the Far West. Farmers on the High Plains adopted a low input and low output strategy of production resulting in lower quality and lower yields than other regions. High Plains farmers were more likely to use strippers instead of spindle pickers, and they have traditionally used fewer chemicals to control insects, diseases, and weeds. Farmers in this region were far more likely to reuse their own seed or buy seed from local producers. As a result, national seed breeding companies largely avoided the region and did not invest in developing better varieties tailored to its needs.

[83] Compiled from USDA, Production and Marketing Administration, Cotton Branch, *Cotton*. The shares are based on 1952 acreage and 1951 ginnings. With the concentration in varieties came a parallel concentration in the number of seed breeders and seed distributors. By 1961, "four large companies produce the cotton seed that is used on 90 percent of the planted acreage in the Southern and Southeastern States." Waddle and Colwick, "Producing Seeds," p. 188.

[84] Porter, "Toward Standardized Cotton," pp. 21-22; Doyle, "One-Variety-Cotton"; U.S. Congress, House Committee on Agriculture, *Research*, pp. 754-55.

[85] See for example, U.S. Congress, *Hearings*, 75th Cong., 3rd Sess., pp. 317-19 and 938-40, and U.S. Congress, *Hearings*, 78th Cong., 1st Sess., pp. 328-29.

[86] U.S. Bureau of the Census, Historical Statistics, Series K553-555.

industry, prominent breeders, leading shippers, and southern bankers all lauded the movement's contributions.[87] In light of the subsequent developments in government policy regarding intellectual property rights in genetic materials, it is important to understand the incentive structure and position of private seed companies regarding one-variety communities. The innovative seed companies faced a number of interrelated problems. Such a firm's primary contribution was its investment in research and development to produce new plant varieties; its value added in cleaning or providing seed treatments was generally secondary. As principally a seller of intellectual property, a seed company had to be able to exert market power and price above marginal cost to recoup its sunk R&D expenses. But even if a company could exercise market power, it faced the problems of a durable good monopolist–namely, it created its own competition–to an especially severe degree. In the textbook view, a durable goods monopolist suffers from the following time inconsistency problem: it has an incentive to sell initially to high-demand buyers at a high price and in subsequent periods lower prices (or equivalently offer improved quality for the same price) to attract the lower-demand buyers. But this threat causes the high-demand buyers to lower the initial price they are willing to offer. The preferred solution for the durable good monopolist is to lease the good, that is, sell the services rather than the good outright. If this proves infeasible, the firm may reduce the inter-temporal competition by reducing the durability of the good (planned obsolescence).[88] Obviously this reduces the value of the good to the buyer and the firm must weigh this negative price effect against the positive effect in sustaining its market power to determine the optimal level of durability.[89]

For seed producers, the problem of inter-temporal competition is especially severe because the seed possesses the natural ability to produce multiple offspring. (For cotton, the multiple was on the order of 10 to 30 to one.) Hence, a farmer could purchase commercial seed to meet a fraction of his requirements and within a few seasons raise enough for his whole operation and have a surplus to sell to his neighbors. The seed companies could partially offset this latter form of competition through quality-control guarantees and branding. But in an environment with weak intellectual

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[87] Merrill, Macormac, and Mauersberger, *American Cotton*, p. 116; U.S. Congress, *Hearings*, 78th Cong., 2nd. Sess., December 4-9, 1944, p. 399; "One-Variety Cotton," pp. 103-104.

[88] These are only a few of the alternatives available. Another preferred solution for the durable good monopolist is to creditably commit to a price schedule or to provide buyback offers.

[89] Bulow, "Durable-Goods," pp. 314-332 and "Economic Theory," pp. 729–49.

property protection, a company could not easily or effectively prevent its gene stock from serving as the basis of a competitor's "improved" variety. These forces help explain why the desideratum for commercial seed breeders was a product without the ability to reproduce naturally; a seed such as a F2 hybrid or one with a Terminator gene.

In recent decades cottonseed companies have been among the most vocal opponents of the one-variety law in California.[90] Breeders also opposed more ambitious New Deal plans for the South. Shortly after the Agricultural Adjustment Administration (AAA) began, leaders of the Cotton Section developed a program patterned on the California model for the South. This was a relatively centralized scheme that would have empowered the directors of the state experiment stations to choose one variety of cotton for communities in their states. The directors were supposed to consider the diversity in growing conditions in defining community boundaries, but the hope was that large areas, possibly entire states, might convert to a single variety. The plan also called for an expansion of government breeding and seed-distribution activities. According to Cully Cobb, who headed the AAA's Cotton Section, USDA Secretary Henry A. Wallace had tentatively signed off on the program, but at the last minute D. R. Coker convinced Wallace to scuttle it.[91]

But it would be wrong to conclude that such opposition was a constant. During the heyday of the one-variety community movement in the South the major seed companies embraced the effort and lent their support in spite of the communities' seed multiplication and distribution policies. In his 1938 article "Break This Vicious Circle Which Shuts You Out From Cotton Seed Sales" that appeared in the inaugural issue of *Southern Seedman*, Austin Burges argued the "opening wedge must be one-variety communities" and that assisting their development "means heavy extra profits for the seed dealer."[92] George J. Wilds, the president of Coker's Pedigreed Seed Company, spread the same message in his 1944 Congressional testimony: "the one-variety community is the best solution for all of us interested in cotton."[93] Seed company marketing policies conveyed the same theme. The USDA noted that "the 1947 catalog

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[90] As an example, in 1964 D&PL purportedly encouraged dissident growers in the San Joaquin Valley to campaign for repeal of California's one-variety law. Camp, "Cotton, Irrigation," p. 172. D&PL began to push its breeder's rights outside of the California context. In the case of *Delta and Pine Land Co. v. Peoples Gin Company* (1982), the U.S. district court in Mississippi ruled that the Plant Variety Protection Act of 1970 prevented the cooperative gin from arranging the sale of collectively ginned cottonseed between its member farmers. Kloppenburg, *First the Seed*, p. 146

[91] Cobb, "Cotton Section," pp. 96-99. Camp, "Cotton, Irrigation" pp. 135-38.

[92] Burges, "Break This Vicious Circle," pp. 5, 6, 29.

[93] U.S. Congress, *Hearings*, 78th Cong., 2nd. Sess., December 4-9, 1944, p. 400.

of the largest commercial cottonseed breeding firm in the Southeast states" (presumably Coker) contained a strong endorsement of one-variety communities, asserting that they had been of great value to breeders, growers, and manufacturers. The company also adjusted its breeding and marketing program to support cotton standardization. Other breeders jumped on the bandwagon. "To further promote standardized production two other large commercial breeders in the Mississippi Valley [most likely D&PL and Stoneville], who furnish the foundation planting seed for the great bulk of the one-variety communities in the Central and Eastern States, have adopted the policy of retaining the same varietal name for their new stocks from year to year, thus simplifying the continued operation of the one-variety developments."[94] Other evidence suggests that up to the early 1950s the major seed companies saw the growth of one-variety communities as a bonanza to increase sales.[95] Dr. C. W. Manning, an early breeder with the Stoneville Pedigreed Seed Company, recalled that his firm gladly sold to one-variety communities knowing full well that they planned to increase the seed and supply it to local farmers. This meant "the company had to put more salesmen on the road."[96] Evidently in this evolutionary stage in the development of the cottonseed business some market was better than no market.

Before World War II, the leading private breeders were typically small and near the margins of commercial viability as stand-alone operations. Coker's Pedigreed Seed Company of Hartsville, SC, the "South's Foremost Seed Breeders," appears chiefly to be the farm improvement hobbyhorse of its wealthy, public-spirited owner, D. R Coker. The firm's weak financial record over the 1920s and 1930s led Coker to consider handing over the operation to a philanthropic organization, such as the Rockefeller

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[94] USDA, Report of the Administrator of Agricultural Research, p. 302.

[95] Well before the onset of the one-variety community movement Coker promoted a plan whereby farmers would buy enough seed for a seed patch and then use the resulting seed to plant their entire crop the following year. Coker catalogs also contained farmer testimonials describing how they made money increasing and selling the improved seed to neighbors. While initially beneficial to seed companies, such policies created competition for the firms' future sales. Seed certification programs and later the Plant Variety Protection Act helped reduce this form of competition. Webb, "Private Cotton," pp. 522-534.

[96] Phone interview by authors with Dr. C. W. Manning of Leland Mississippi, February 1, 2002. Manning's statement referred to the period around 1950. Early C. Ewing, Sr., the head breeder at D&PL also linked the increased popularity of improved seeds with "the phenomenal growth of one-variety communities, one-variety gins, and one-variety farms…." Early C. Ewing, "History of Cotton Varieties," D&PL Company Records, Box IX, "History: Published Material," D&PL archives.

The support that the seed breeders in the 1940s and 1950s gave the one-variety communities is somewhat analogous to the support book writers and publishers might provide public libraries in areas dominated by illiteracy. From the book trade's commercial standpoint, it would be better if each reader bought the book and could not resell it or share it with others (although advertising it by word-of-mouth would be welcome).

Foundation, to support as a southern improvement project.[97] The leading commercial breeding operation in the mid-South was a subdivision of the Delta and Pine Land Company (D&PL), a 38,000-acre plantation in the Mississippi Delta. Building on its success in creating early maturing, high yielding, high quality seed for its own lands, D&PL became a major seed supplier. According to *Fortune*, the company sold "more cottonseed to planters than any other single world agency" in the mid-1930s.[98] Yet for all of D&PL's prominence, its sales over the 1925-1934 decade averaged only about 1,060 tons per year, which represented less than one percent of the seed planted for the U.S. cotton crop. Figure 3, graphing D&PL sales from 1925 to 1964, shows that this situation changed significantly after the one-variety movement took hold. The series reveals many ups and down reflecting weather conditions and inter-firm competition.[99] Despite a 62 percent reduction in U.S. cotton acreage and a more than 50 percent decline in seeding rates, D&PL sales over the 1955-64 period were over seven times those prevailing 30 years earlier.

It is possible to obtain a summary view of the change in the source of seed supply. According to various accounts the vast majority of seed used before 1930 was "gin run." As noted above, Doyle asserted that in the 1920s and in the early 1930s only 5 to 10 percent of cotton planting seed came from breeders and dealers. By 1955, purchased seed made up 74 percent of the cottonseed used for planting.[100] Notably, 70 percent of the purchased seed and 52 percent of all planting seed in 1955 was comprised

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[97] Rogers and Nelson, *Mr. D. R.*, pp.152-73, 197; Coclanis, "David R. Coker," pp. 105-114.

[98] "Delta & Pine Land Co.," p. 158.

[99] For example, bad weather wiped out the seed crop in 1937. Later the company subcontracted seed production to reduce climatic risks. Compiled from Annual Statements and President's Reports, D&PL Company Records, Box 2, D&PL archives.

[100] U.S. Bureau of the Census, *Census of Agriculture 1954,* p. 19. The survey shows that 583,000 farmers purchased 194,100 tons of cottonseed for planting. This information, together with the 1954 Census production data, implies that purchased seed was used on over two-thirds of cotton farms. The total amount of cottonseed used for planting comes from Table 192 of USDA, *Statistics*, p. 232.
Paralleling the one-variety community movement was a more general campaign to improve seed varieties centered on the activities of the International Crop Improvement Association. The Association was chartered in 1920 with members from across the United States and Canada. The aims were to limit fraudulent practices in the seed business, prevent the loss of valuable varieties as a result of contamination with other varieties, and develop international standards for seed identification and distribution. The Association developed field and laboratory standards, regulations to ensure proper isolation and handling of seed breeding and increase programs, a system of uniform seals and tags to identify pure seed, and uniform definitions for classification and certification. The Association also successfully lobbied to obtain legal backing for its standards. The Association established uniform cottonseed certification standards in 1926. As the terminology evolved, "foundation seed" was developed by the breeder; "registered seed" represented the first year's multiplication of foundation seed (under tightly controlled conditions); and "certified seed" represented the multiplication of registered seed (again, under controlled conditions). Hackleman and Scott, *History*, pp. 1-67.

of certified seed.[101] In 1971, only about 19 percent of cotton farms nationally (with 19 percent of acreage) planted seeds they grew themselves. The fractions were even lower if Oklahoma and Texas are excluded. Outside of these states, 15 percent of farms (with 13 percent of acreage) reported using homegrown seed. At this time, certified seed was planted on 64 percent of cotton farms nationally (and 74 percent of those outside Oklahoma and Texas).[102]

The timing of the takeoff in the adoption of improved seed varieties clearly predates adoption of the mechanical harvester because between 1940 and 1945 the acres of certified cottonseed planted in the United States tripled. (See Table 7.) In 1940, there were 98,000 acres approved to produce certified cottonseed. At prevailing seed yields (0.236 tons per acre over the 1946-48 period) and seeding rates (32 pounds per acre), the output of this acreage would have been sufficient to plant less than 6 percent of U.S. cotton land (outside California). By the 1952-54 period, there was an average of 577,000 acres approved, producing sufficient certified seed for over half of U.S. cotton land (outside California). Moreover, the average quality of non-certified seed also increased, because it was apt to be only a few generations removed from certified seed. After the mid 1950s the number of approved acres fluctuated, but the percentage of the crop planted with certified seed continued to grow because with improved seed varieties, delinting (see below), and improved mechanical seeders, the amount of planting seed required per acre of cotton declined substantially.[103]

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[101]The data on certified seed come from Saunders, *Report 1954*, pp. 47-50 and 102. The certified seed data omit seed produced by government agencies in California (and likely in other states) and thus understate the total production of high quality seed. The shares reported in the text include our estimates for the pure seed used in California.

[102] U.S. Bureau of the Census, *1969 Census*.

[103] Hackleman and Scott, *History*, p. 53. Acres planted come from USDA, *Statistics*, p. 63. By 1980, nearly all planting seed outside the High Plains was certified. Although early accounts claimed that delinting saved about 20 percent of the planting seed, increases in seed quality and improved cultural methods led to further declines. Between the 1930s and the 1990s, seed planting rates outside the High Plains declined from about 34 pounds per acre to as low as 8 pounds an acre.

The general seed literature often presents figures indicating that in the recent period U.S. planting cottonseed is split 50-50 between homegrown and commercial sources. See, for example, Butler and Marion, *Impacts*. This view is incorrect. In tracking back the citation chain, we have found no solid basis for this conventional estimate. Indeed, it conflicts with 1971 survey results in the special report on cotton in the *1969 Census of Agriculture.*

THE DEMISE OF THE ONE-VARIETY MOVEMENT

By the mid-1950s the USDA had de-emphasized its one-variety community campaign in the South. After 1952, the USDA Bureau of Plant Industry "relinquished much of its part" in the one-variety program and began closing many of its regional offices. By the end of 1954, the program was "turned over to the agricultural extension services."[104] In roughly the same period, the Agricultural Marketing Service also de-emphasized the requirement that farmers be members of a cotton improvement group, opening up Smith-Doxey classification to farmers who contacted their county agents.[105] From the USDA's perspective, the program had served its purpose of educating farmers of the importance of growing high quality cotton and a number of technological and institutional changes made the one-variety concept less appealing. The maturation of a commercial seed industry able to supply abundant quantities of high quality foundation seed was an important reason for the demise of one-variety communities in the traditional Cotton South. With the increased presence of quality private breeders and strict new seed certification systems, the seed increase activities of one-variety communities became unnecessary. At this juncture the South took a different path than California where a legally entrenched bureaucracy, with its own internal seed-breeding program, prevented competition from private breeders. Southern one-variety communities, which were more loosely organized and did not have in-house research and breeding operations, were always dependent on private breeders or experiment stations for their foundation seed.

The development of high-quality varieties that gained favor over wide areas was just one of a series of economic and technological changes that made one-variety communities obsolete in the South and may help account for the finding that California's system was inefficient by the late 1970s. Among the most important of these changes was the development and diffusion of acid delinting (and later other chemical treatments) of planting seed. This technology would eventually strengthen the position of commercial seed companies, increase on-farm productivity, and facilitate the mechanization of the last major bastion of hand labor in the production of cotton.

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[104] Westbrook, "One-Variety Cotton," p. 17. In most areas of the South, the state extension services had folded the one-variety program into the new "Seven-Step Cotton program" beginning in 1945. This program also addressed emerging issues such as cotton mechanization and chemical application. USDA, *Report of Cooperative Extension Work, 1946*, p. 29.

[105] USDA Agricultural Marketing Service, "Get Your Green Card," pp. 4-5. The Smith-Doxey services continue to this day, although the program is now called Form 1 classification.

When upland cotton is ginned, the seeds remain "fuzzy" because the gin fails to remove all of the lint. Throughout the ages farmers planted fuzzy seed and then chopped (thinned) the cotton plants to obtain an even stand. Chopping cotton was a labor-intensive activity, requiring nearly as many worker-hours as picking. Fuzzy seed worked poorly with mechanical seeders because it would clump together and clog the machines. Clumping also made obtaining a well-spaced, uniform stand difficult whether the seed was planted by hand or by machine. More precise planting to a row greatly reduced the need for chopping, increased yields, and allowed for more efficient machine cultivation.[106] The solution was to delint the cotton, using one of several technologies. In California, the use of machines to delint planting seed dates to the beginning of the industry and was widespread by the 1940s.[107] By the 1950s the technology had gained popularity in the Cotton South, and it remained the most common form of delinting to the early 1970s.[108] Essentially the cotton was reginned using special machinery designed to remove most of the lint. This helped in planting with machines, but the remaining lint still made it difficult to obtain an even stand, and thus the need for chopping continued. The next stage was to expose the mechanically delinted seed to an intense flame to burn off the remaining lint. This improved the seeds' handling characteristics but not sufficiently for precision metering during planting.[109] The ultimate solution was to use one of several acid processes to chemically delint the seed. Besides allowing farmers to mechanize seeding operations and dispense with chopping, acid delinted seed offered several other advantages. Delinting (and indirectly the more even spacing of plants) allowed cotton to come to a stand earlier, which was a real plus, especially given the threat of the boll weevil. In addition, acid delinting reduced plant diseases and greatly increased germination rates. For these reasons, farmers need much less planting seed.[110]

Delinting cottonseed with acid on the farm was an unpleasant and hazardous task. Experiment station reports provided detailed instructions on how to prepare the

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[106] Alexander, *Arkansas*, p. 81; Hopper and McDaniel, "Cotton," p. 299.

[107] Camp, "Cotton Culture," p. 8.

[108] Machine delinting in the South was common earlier because the linters had value, especially during World War I when they were used to make munitions. Agelasto, et al., "Cotton," pp. 381-83. Evidence on the use of delinted seed for planting is sparse, but as early as 1922 D&PL's standard practice was to sell mechanically delinted seed. Delta and Pine Land Co. of Mississippi, *Salisbury Cotton,* D&PL Records, Box 1, Oral History, D&PL archives.

[109] Cherry and Leffler, "Seed," pp. 531-33.

[110] Hancock, "New Method," pp. 1-2. Accounts differ on the decline in planting seed per acre. Hancock notes savings of 20 percent, but Alexander notes that planting delinted cotton "utilizes less than one third the amount of seed needed for ordinary cotton production…." Alexander, *Arkansas*, p. 81.

acid and soak the seeds, noting the obvious: "**Never add water to the acid,** as this causes a violent reaction."[111] For all the benefits, the cost of the acid and the unpleasantness of the task sharply limited the number of cotton farmers adopting the delinting technology.[112] But H. P. Smith saw the handwriting on the wall in 1950 when he noted that "most cotton growers plant regularly ginned seed which are covered with fuzzy lint. Mechanization may be influencing the trend toward delinted seed."[113] In the 1960s with the development of improved acid technologies and with the advent of the mechanical cotton harvester, the acid processes began to compete more effectively with machine delinting.[114] In 1970 P. R. Smith estimated that roughly 95 percent of U.S. planting seed was delinted, with acid delinting accounting for 23 percent of the planting seed in California, about 90 percent in Texas and Arizona, 15 percent in the Mid South, and 40 to 50 percent in the Southeast.[115]

The adoption of delinting (and especially acid processes) reflects the interaction effects of mechanical and biological technologies as the diffusion of one reinforced the demand for the other. It was in the interest of farmers to have ample labor during the peak season. Thus, as an example, adopting tractors that would save labor in plowing would only exacerbate the imbalance between the peak and non-peak needs, potentially leading to labor shortages during the peak period. Farmers who adopted a mechanical picker had an added incentive to reduce chopping labor requirements, and planting acid delinted seed made that possible. Moreover, the new planting technologies made the mechanical picker much more efficient. If plants are too widely spaced, they develop woody branches that hinder machine performance. With delinted cotton and a mechanical seeder, farmers could achieve a thick, uniform stand suitable for efficient

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[111] Sherbakoff, *Improved Method*, p. 2. Bold type is in the original.

[112] Brown's comment that "some authorities recommended delinting cotton seed that are to be used for planting purposes," suggests the lack of adoption in 1938. Brown, *Cotton*, 2nd ed., p. 212. In 1943, Alexander still asserted that delinting was relatively expensive. Alexander, *Arkansas*, p. 81. In the mid-1950s Christidis and Harrison still recommended machine rather than acid delinting. They noted that the later processes were only "occasionally" used. Christidis and Harrison, *Cotton*, pp. 310-11.

[113] Smith, "Cultural Practices," p. 144.

[114] Elliot, Hoover, and Porter, *Advances*, pp. 125-26.

[115] Smith, "Introductory Remarks," p. 90. Smith claimed that 70 percent of the planting seed in Georgia was acid delinted. Leaders in the development of the California cotton industry maintain that acid delinting came much earlier than Smith claimed. In Arizona acid delinting appears to have been gaining wide favor as early as 1938, and at least one commercial delinting plant was in operation by that date**.** "Much Delinted Seed," p. 4. Beginning in the 1938 the firm of Feffer-Wharton regularly advertised its acid-delinting services. Feffer-Wharton, March 1, 1938, p. 4 and March 15, 1938, p. 17. By 1962, 90 percent of D&PL seed sales in Arizona were acid delinted. Sales Department Review, April 1962, Box 19, D&PL archives.

machine operation, and eliminate most of the labor required for chopping.[116] The result was that whereas acid delinted seed was rare in 1950, it was gaining acceptance in the 1960s, and nearly universal by the late 1970s.[117]

The new cottonseed delinting technologies offered significant economies of scale with the production of delinted seed typically concentrated in a few plants in any one state.[118] The adoption of delinted seed had enormous implications for the growth of the commercial cottonseed industry that were analogous to the implications of hybridization to seed-corn producers. Corn farmers had to purchase new seed every year because pure-line F2 hybrids lost their vigor in a single generation. But the improved cotton varieties were not F2 hybrids and thus farmers could recycle seeds, significantly reducing the demand for new commercial seeds. But delinting dramatically increased the economic benefits of purchased seed relative to gin-run seed, stimulating farmers in most regions to buy seed annually. This single technological change greatly reinforced the benefits that cottonseed companies received in 1970 with the passage of the Plant Variety Protection Act.

Along with delinting came a number of other chemical treatments to control diseases and insects. The upshot was that cottonseed in the 1960s not only was higher quality in terms of its yield potential than seeds of the 1930s, the modern seed embodied numerous other valuable technological features. Thus by the late 1970s (at the time of Constantine, et al.'s estimates for California) a new division of labor had been firmly established. In most regions nearly all farmers bought delinted certified seed nearly every year. The old practice of planting one's own seed obtained at the gin had become a rarity. The new seeds were produced in tightly controlled isolated areas to help guarantee purity. This change in seed technology, certification, and marketing, along with the development of superior varieties that effectively captured the market in whole

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[116] In addition the higher yields that came with improved seed and delinting directly stimulated the mechanization of the harvest by allowing the fixed cost of the machine to be spread over a larger volume of output. Musoke and Olmstead, p. 402.

[117] In 1961 Waddle and Colwick noted that "delinting…is common throughout the Cotton Belt. Chemical delinting, mechanical delinting, and flame delinting are used." Waddle and Colwick, "Producing Seeds," p. 190. Advances in chemical delinting technology included a dry system in which hydrochloric acid was mixed with sulfuric acid to form a gas that reacted with and crystallized the fuzz on the seed. The seeds were then treated to remove the crystallized lint. The various steps of the wet acid process were also integrated and mechanized in large delinting facilities.

[118] Around 1970 there were only four or five acid delinting plants in California, and only three in Mississippi. In recent decades the production and delinting of planting seed for the entire South has largely moved to the arid west where weather conditions pretty much ensure that the seed will not get wet. Many of the delinting operations have moved to Indian reservations, outside the reach of the Environmental Protection Agency. In addition, new technological advances in developing a foam delinting process have greatly reduced the negative environmental side effects.

regions or states, simply ended the need for formal one-variety communities. It mattered little if seed was mixed at the gin if it was not intended for planting. In addition, the problem of cross pollination in the field was minimized by the annual purchase of new seed, the *de facto* one-variety production, and the decades of insecticide use that reduced the density of insects.[119] The old production externalities that had haunted the industry were no longer an issue. In addition the nearly universal use of Smith-Doxey classification services, and later the adoption of extremely accurate high volume electronic testing devices (HVI), largely solved the problems of classing cotton. Thus, with the major exception of California, one-variety communities simply faded away, having served their purpose in helping promote the transition to better cottons and improved cultural and marketing practices.

CONCLUSION

In 1957 James Street published his classic, *The New Revolution in the Cotton Economy*. For Street the cotton revolution involved a wholesale transformation in cotton production — a transformation that was critical for the modernization of the southern economy. But Street's story of technological change focused largely on mechanization, with only occasional mention of cotton breeding and improvement activities, and then usually in the context of how breeders were assisting in the drive to develop plant qualities conducive to mechanizing the harvest.[120] The message of this paper is to emphasize the importance of the other revolution in the cotton economy. Biological and structural rather than mechanical, this revolution led to a fundamental change in the source of seed supply, in the varieties of cotton grown, and how cotton was classed and marketed. One of America's leading cotton breeders, J. Winston Neely offered a perspective of recent accomplishments as of the late 1950s:

> …the progress made by cotton breeders is truly phenomenal. Yields have been markedly increased. Varietal resistance to diseases, resulting from breeding programs, has made profitable the growing of crops where non-resistant varieties would fail completely. The quality of fiber produced by improved varieties has been greatly

[119] Yet a final factor in the demise of one-variety communities was the development of High Velocity Instruments that could rapidly and accurately quantify the important characteristics of cotton samples, and the increased ability of mills to handle less uniform cotton. These innovations reduced the premium to uniform production.

[120] For example, see Street, *New Revolution*, pp. 112-13 and 147-48. Street's emphasis is consistent with the broader treatment of technological change in agriculture. As an example Peter McClelland's recent book *Sowing Modernity* has a chapter on sowing that offers marvelous detail on the machines that sowed the seeds, but almost no mention of the changing qualities of the seeds fed into the machines. McClelland, *Sowing Modernity*, pp. 64-93.

> increased. Characteristics of plant type, growth habit and fiber quality of many varieties have been altered by breeding, to the extent that they are much better adapted to cheaper and better methods of planting, culture, harvesting and processing. We would be growing far less cotton today if we had to depend upon varieties grown only a few years ago.[121]

These changes, rather than the arrival of the mechanical picker, accounted for the roughly tripling of American cotton yields and the increases in average staple length between 1930 and 1960.[122] As Neely noted, the new biological technologies interacted with mechanical technologies reinforcing the drive to increase southern agricultural productivity. Because of these interaction effects with mechanical technologies, the new biological systems had a far greater effect in reducing labor demand than analogous biological innovations in the grain sectors.

But what fundamentally separated the biological revolution in cotton from what transpired in corn and most other crops was the greater role that the USDA played in orchestrating institutional innovations. In the nineteenth and early twentieth centuries, USDA research programs played a key role in improving the quality of seed supplies of most major crops. USDA scientists searched the globe for useful varieties, and government breeding, testing, and outreach programs made an enormous contribution to help transform the seed supplies available to American farmers.[123] In addition, the USDA focused on improving the efficiency of seed markets. Seed embodies a complex array of technical characteristics that are difficult for an individual farmer to assess. Evaluations about the relative performance of different varieties and the quality of a given batch of seed (was it cleaned and stored properly, etc.) usually must wait until the harvest; and given annual variations in growing conditions, several years may be required to make a reliable assessment. As a result, the development of a market in seed requires particularly good information and mechanisms for providing guarantees to farmers and building trust between seed buyers and sellers.[124] For most crops, the USDA (often following the lead of individual states) helped to develop national procedures, laws, and agencies for testing and certifying the genetic and physical characteristics of seed. But in the case of cotton, the task of market development was

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[121] Neely, "Cotton," p. 74.

[122] As with corn, other factors such as the application of improved fertilizers, herbicides, and insecticides clearly contributed to cotton yield increases.

[123] Olmstead and Rhode, "Red Queen."

[124] Tripp, "Institutional Conditions," p. 24.

complicated by the exceptional problems in maintaining pure seed supplies, and the failure of the system of local cotton classing to reflect the relative premiums and discounts prevailing in central markets. These problems combined with the relative lack of education and the more depressed conditions in the Cotton South created formidable barriers to technological diffusion which in turn dampened the incentive for private breeders to invest in creating improved cotton varieties.

The one-variety community movement and Smith-Doxey classification system represented the vehicles for a comprehensive reform program that included educational campaigns and seed certification systems. The goal was to fundamentally redesign both the production and marketing of cotton in order to shock the cotton economy out of the prevailing low-productivity equilibrium.[125] Within a few years of the beginning of these efforts local reports were touting improved yields, longer staple length, and greater price premiums. By the late 1940s over 400,000 cotton farmers, producing roughly 60 percent of American cotton output, were in one-variety communities. Institutional and technological changes, along with the development of private sector seed companies, gradually eroded the advantages of one-variety systems. In the South they simply faded away. In California, the one-variety law and institutions were harder to dispose of, and the system persisted into the 1990s, long after it evidently had become obsolete.

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[125] It is important to note that the problems of maintaining pure seed supplies and of grading cotton were not unique to American growers, and that other countries, including Egypt, Brazil, Argentina, and India, experimented with one-variety communities as a solution in the 1930s and 1940s.

Table 1: Average Staple Lengths (in 32ds of an inch)

	1880	1913	1928-30
Alabama	32.9	29.8	28.4
Arizona			32.8
Arkansas	33.2	30.4	31.2
California			33.8
Florida			28.8
Georgia	34.1	30.6	29.0
Louisiana	34.2	31.4	31.0
Mississippi	33.5	31.4	32.8
Missouri			31.0
New Mexico			33.5
North Carolina	33.9	29.3	29.7
Oklahoma		32.6	29.7
South Carolina	39.5	29.8	30.4
Tennessee			29.9
Texas	34.4	31.4	30.0
Virginia			29.2
Other			33.7
United States	34.3	30.8	30.3

Sources: Compiled from Hilgard, *Report*; Taylor, *Relation*;
and U.S. Bureau of Agricultural Economics, *Grade*, pp. 20-21.
United States is average of available states weighted by output

Table 2: Average Price Differential between 34 and 28 Staple Cottons, 1928-36 (in cents per pounds)

Season	(1) Local Markets	(2) Central Markets	(3) Ratio (1)/(2)
Panel 1			
1928	0.45	1.65	0.27
1929	0.37	1.98	0.19
1930	0.18	1.55	0.12
1931	0.23	1.03	0.22
1932	0.12	0.8	0.15
Panel 2			
Market			
w/o PCS			
1933	0.16	1	0.16
1934	0.82	1.48	0.55
1935	0.21	--	--
1936	0.58	--	--
w/ PCS			
1933	0.21	0.47	0.45
1934	0.38	1.33	0.29
1935	0.54	0.95	0.57
1936	0.84	1.52	0.55

PCS = Public Classification System

Sources: Howell and Burgess, *Farm*; and Howell and Watson, *Cotton*.

Table 3: Cotton in One-Variety Communities, 1934-49

	Counties Participating		Communities	Grower	Production of adopted varieties			
					Acres		Bales	
Year	Number	Percent	Participating	Members (thousand)	Number (thousand)	Percent %	Number (thousand)	Percent %
1934					589	2	nd	nd
1935	161	19	331	nd	788	3	571	5
1936	234	28	511	nd	1,470	5	1,112	9
1937	312	38	730	nd	2,453	7	1,883	10
1938	425	33	1,056	nd	2,284	9	1,445	12
1939	495	62	1,516	132	2,987	12	1,656	14
1940	548	70	1,922	185	4,518	18	2,742	22
1941	550	71	2,116	229	6,239	27	3,367	32
1942	577	75	2,564	292	7,614	33	4,570	37
1943	549	77	2,544	306	8,869	40	4,771	43
1944	581	80	2,194	299	7,226	36	4,762	39
1945	500	72	1,800	319	7,071	40	4,172	45
1946	485	70	1,601	310	6,808	39	4,350	50
1947	nd	nd	1,963	331	8,537	40	5,659	48
1948	531	77	2,275	353	11,549	50	9,511	64
1949	546	79	2,422	426	13,500	49	9,500	59

Sources: Compiled from U.S. Congress, *Hearings*, 80th Cong., 1st Sess., Part 2, October 10, 1947; USDA *Report of the Administrator*, 1948, p. 319; Brown and Ware, *Cotton*, p. 58; U.S. Congress, *Research*, 81st Cong., 2nd Sess., December 21, 1950, p. 753; USDA, *Report of Cooperative Extension Work,* 1950, p. 21; and USDA, *Report of the Chief*, 1941.

Table 4: Cotton growing in standardized one-variety communities

State Totals for 1946

State	Counties Participating		Communities Participating	Grower Members	Production of adopted varieties			
					Acres		Bales	
	Number	Percent			Number (thousand)	Percent %	Number (thousand)	Percent %
Alabama	53	83	263	39,225	610	40	386	48
Arizona	6	100	9	954	151	100	143	100
Arkansas	30	57	229	10,788	580	36	546	44
California	7	100	7	5,509	339	100	435	100
Georgia	84	81	241	38,417	574	47	315	57
Kentucky	2	67	2	496	10	97	8	97
Louisiana	26	70	29	22,238	404	51	133	53
Mississippi	61	81	185	49,605	867	38	410	37
Missouri	8	100	126	7,654	272	89	272	89
New Mexico	5	100	5	4,117	130	98	145	98
North Carolina	33	69	38	27,800	332	58	259	62
Oklahoma	29	59	51	13,871	271	27	78	30
South Carolina	26	62	30	26,554	421	46	329	47
Tennessee	22	79	29	26,898	345	57	291	57
Texas	91	57	354	35,955	1,499	25	508	36
Virginia	2	33	3	265	3	13	1	9

Source: U.S. Congress, *Hearings*, 80th Cong., 1st Sess., Part 2, October 10, 1947, p. 962.

Table 5: Farmer Participation in the Smith-Doxey Cotton Grading Program

Crop Year	Cotton Improvement Groups		Samples Classed	Share of US Cotton
	Number	Members	(1000 bales)	Production
1938	312	18,589	84	0.7
1939	918	64,399	265	2.3
1940	1,573	128,216	1,531	12.4
1941	2,511	278,782	2,520	24.0
1942	2,465	281,100	3,567	28.7
1943	2,459	281,493	3,337	30.1
1944	2,410	321,284	4,037	34.4
1945	2,444	343,000	2,888	33.0
1946	2,515	343,700	2,574	30.3
1947	2,453	346,500	4,300	37.3
1948	--	371,061	8,067	55.3
1949	--	497,064	10,456	65.1
1950	--	507,873	5,215	53.2
1951	--	495,391	9,844	65.3
1952	--	515,711	9,382	62.0
1953	--	--	12,700	77.0
1954	--	--	--	--
1955	--	--	--	81.0
1956	--	551,077	11,200	85.0
1957	--	--	--	--
1958	--	--	--	93.0
1959	--	--	--	95.0
1960	--	--	--	96.0
1961	--	699,632	13,703	96.0
1962	--	691,670	13,510	91.0
1963	--	678,749	14,016	92.0
1964	--	--	--	--
1965	--	--	14,311	96.0

Sources: Betts, “Green Card,” pp. 13-16; U.S. Office of Marketing Services, *Report*, 1942/43, p. 111; 1943/44, pp. 44-47; 1944/45, pp. 20-24; USDA, *Report of the Administrator of the Production and Marketing Admin.*, 1946, p. 36; 1947 pp. 33-34; 1948, p. 39; 1950, pp. 11-14; 1951 p, 13; 1952, pp. 19-20; 1953, p. 11; USDA, *Report of the Secretary*, 1956, p. 35; 1957, p. 39; 1959, p. 41; 1960, p. 41; 1961, p. 41; 1962, p. 41; 1966, p. 90; U.S. Congress, Agricultural Department Appropriation Bill for 1954, p.1734; 1955, pp.1031; 1963, p.1249; 1964, p.1344; 1965, p. 84; 1967, p. 548

Table 6: Cotton Variety Concentration by State in 1954

	Percent of Acreage Planted To:	
State	One Variety (percent)	Two Varieties (percent)
Alabama	37	68
Arizona	81	86
Arkansas	62	77
Georgia	60	80
Illinois	72	90
Kentucky	83	98
Louisiana	84	89
Mississippi	76	82
Missouri	40	70
Nevada	100	100
New Mexico	57	66
North Carolina	98	99
Oklahoma	26	46
South Carolina	95	97
Tennessee	57	78
Texas	11	21
Virginia	95	96

Source: Compiled from Brown and Ware, *Cotton*, pp. 53-56.

Table 7: Acreage and Production of Certified Cotton Seed, 1940-57

	Acres Approved for Certification (Thousands of Acres)				**Certified Cotton Seed Production** (Thousands of Tons)			
Year	Foundation	Registered	Certified	Total	Foundation	Registered	Certified	Total
1940				98.0				
1945				296.0				
1946				297.7				70.4
1947				436.5				94.5
1948				506.3				129.4
1949				558.9				49.1
1950	10.4	169.1	271.0	450.5	2.9	34.1	70.1	107.1
1951	6.5	225.9	406.9	639.3	1.4	44.5	95.7	141.6
1952	9.5	277.4	414.6	701.5	2.8	76.2	104.2	183.2
1953	7.7	216.0	343.4	567.1	2.5	80.7	89.2	172.5
1954	4.9	183.7	272.9	461.4	1.4	58.5	85.5	145.4
1955	8.4	62.5	294.3	365.2	3.1	21.7	98.9	123.6
1956	6.9	120.9	246.3	374.1	2.4	34.0	61.6	98.0
1957	7.5	94.4	201.8	303.7	3.3	23.7	83.1	110.1

Sources: Hackleman and Scott, *History*, Appendix 1, p. 53; Fisher, *Report,* 1946 and 1947; Beeson, *Report*, 1948, 1949, 1950; Saunders, *Report*, 1951, 1952, 1953, 1954, 1955, 1956; Hill, *Report*, 1957, 1958.

Notes: Acreage and output exclude California activity.

Figure 1: Yield per Acre of US Cotton and Corn, 1866-1995

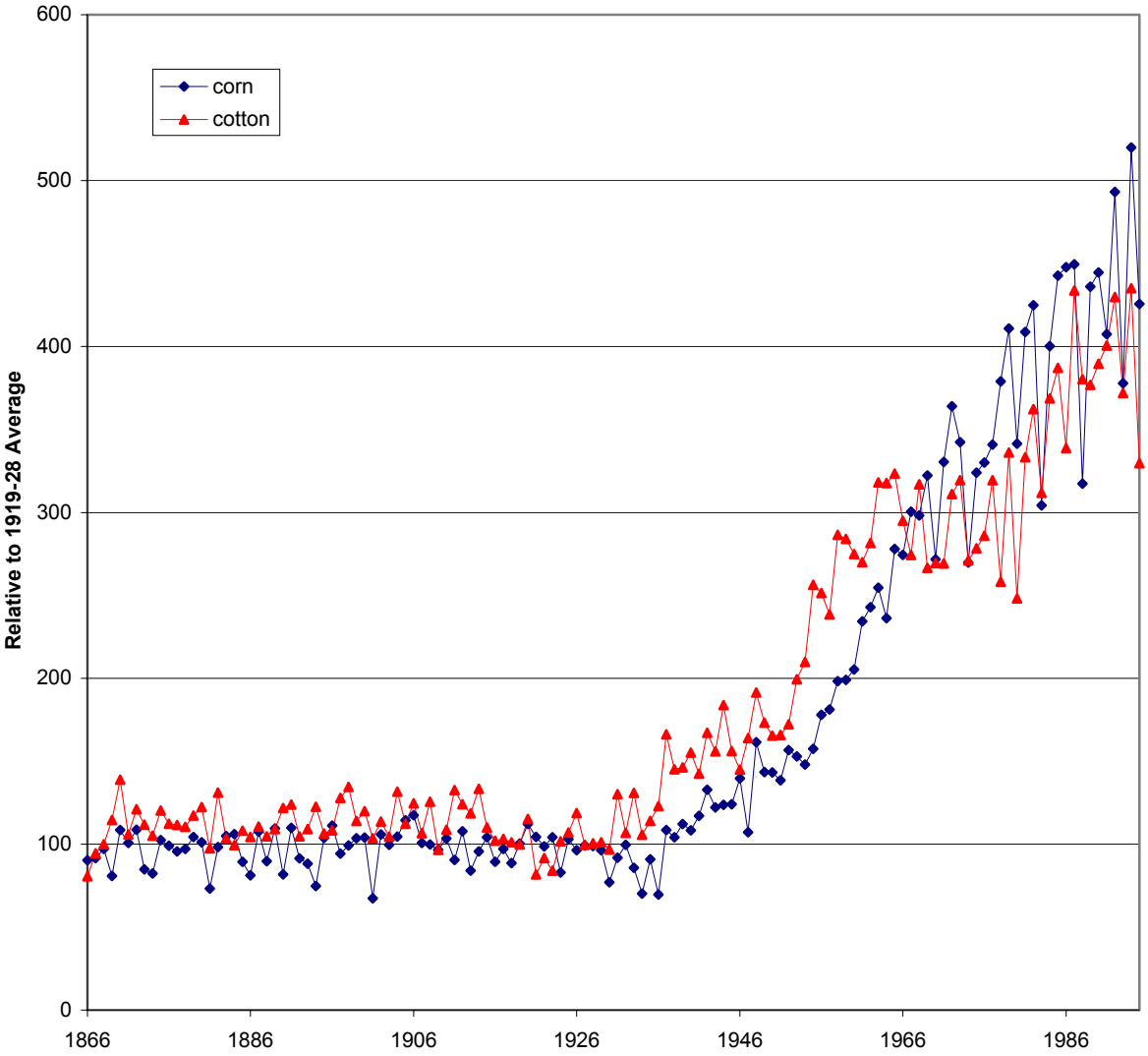


Figure 2: US Cotton Staple Length Distribution, 1928-57

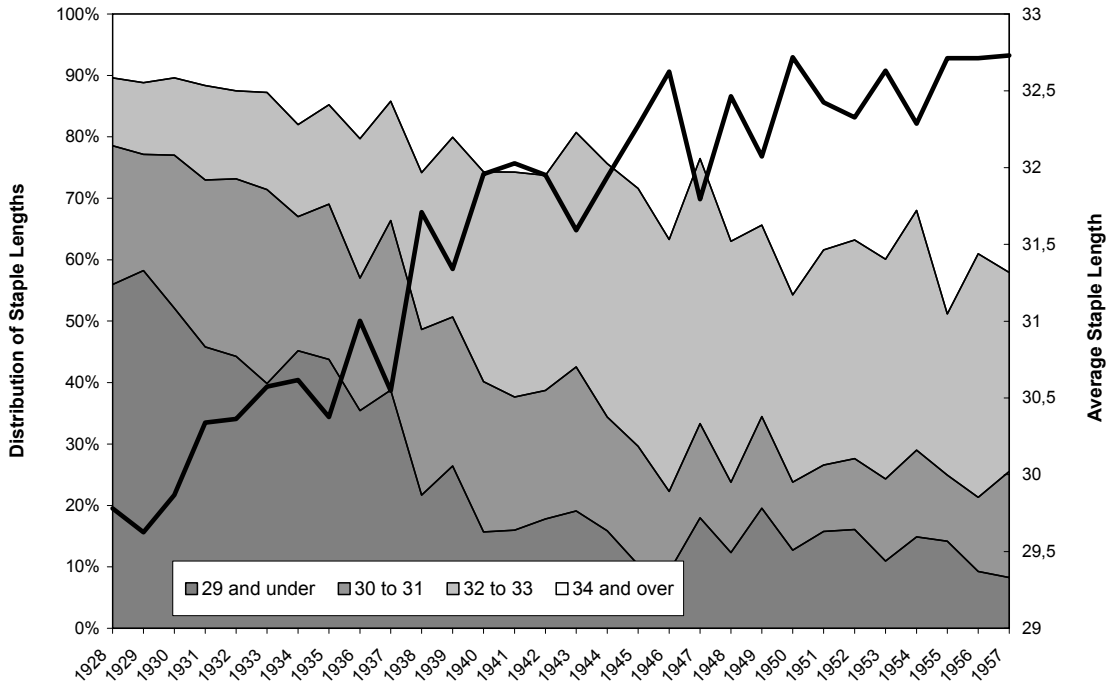
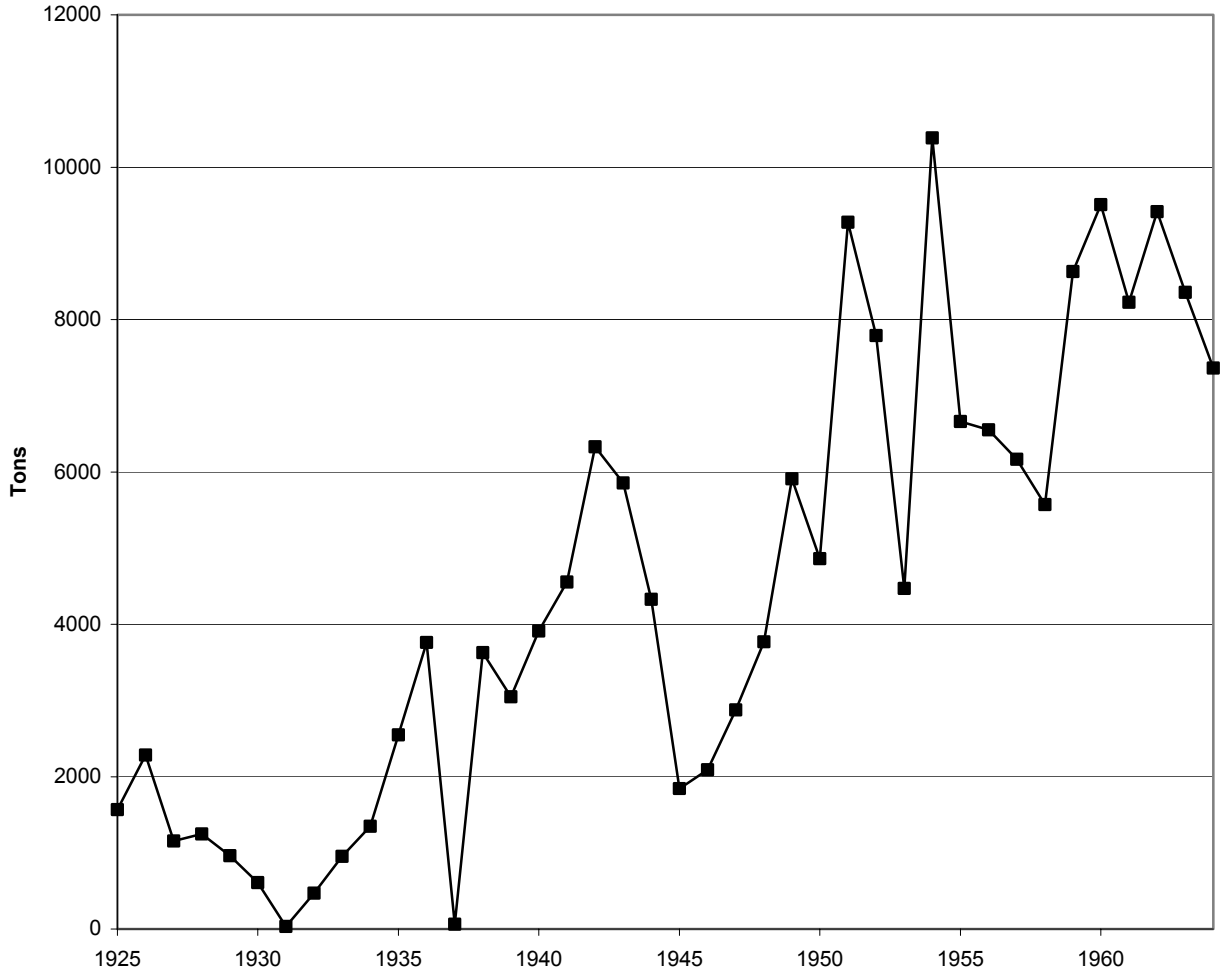


Figure 3: Sales of Planting Cottonseed of the Delta and Pine Land Company, 1925-64



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